Knowledge.

With which is incorporated Hardwicke's Science Gossip, and the Illustrated Scientific News.

A Monthly Record of Science.

Conducted by Wilfred Mark Webb, F.L.S., and E. S. Grew, M.A.

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SYNTHETIC RUBBER.

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(*Continued from page 40.*)

We now come to discuss methods for obtaining butadiene and isoprene from starch, which, next to cellulose or wood, is the most abundant of all vegetable material, occurring in cereal grains and potatoes.

There are several methods of transforming starch into isoprene. One of the processes now actually being worked is known as the "fusel oil" route, and was first suggested by Dr. F. E. Matthews, of the Synthetic Products Company.

Maize or potatoes are made into a mash with water, which is then inoculated with new varieties of bacteria discovered by Professor A. Fernbach, of the Pasteur Institute of Paris, and the whole is allowed to ferment for about a week in a special vat (see Figure 31), when about forty-two per cent. of the starch contents were found by Dr. Otto Hehner, the well-known analyst, to have been converted into fusel oils, the main constituent being butyl alcohol. Figure 45 shows the vats now being erected by the Synthetic Products Co., for the manufacture of fusel oil on a commercial scale. By varying the conditions of fermentation *acetone* can be obtained at the same time in large quantities.

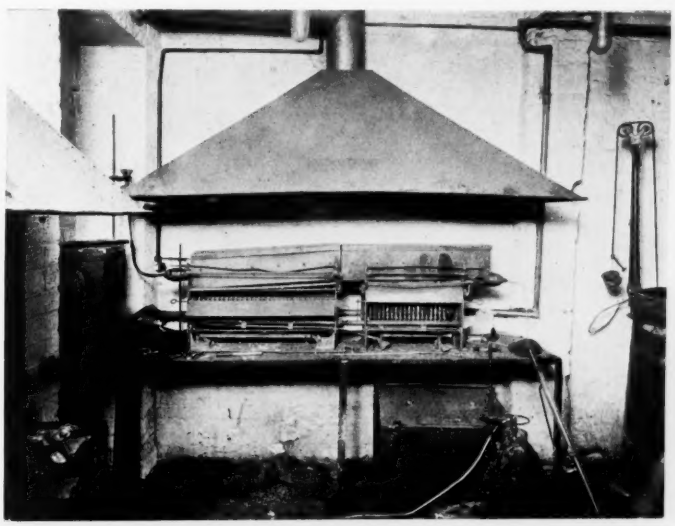


FIGURE 42.

Messrs. Strange & Graham's Apparatus for the production of butadiene from butylene dichloride.

Next, the fluid is removed from the vat and is distilled, whereby the fusel oils and acetone are separated from the watery residues. Next, into the heated fusel oil a stream of dry hydrochloric acid gas is passed (which, as every schoolboy knows, is made by the action of sulphuric acid on common salt), when monochlorides are formed thus:—

$$\underset{\text{Butyl Alcohol.}}{CH_3CH_2CH_2CH_2OH} + \underset{\substack{\text{Hydrochloric}\\\text{Acid Gas.}}}{HCl} = \underset{\text{Butyl Chloride.}}{CH_3CH_2CH_2CH_2Cl} + \underset{\text{Water.}}{H_2O}$$

The butyl chloride thus obtained is then treated

with chlorine gas to convert it into dichlorides, thus :—

$$\underset{\text{Butyl Chloride.}}{CH_3CH_2CH_2CH_2Cl} + \underset{\substack{\text{Chlorine}\\\text{Gas.}}}{Cl_2} = \underset{\text{Butylene Dichloride.}}{CH_3CHClCH_2CH_2Cl} + \underset{\substack{\text{Hydro-}\\\text{chloric Acid.}}}{HCl}$$

Dichlorides of the formulae $CH_3CH_2CHCl.CH_2Cl$ and $CH_2Cl.CH_2CH_2CH_2Cl$. are simultaneously formed.

If chlorine acts unrestrainedly upon the butyl chloride other products in addition to dichlorides are produced. A special apparatus had to be invented so as to remove the dichloride as rapidly as it is formed. The apparatus of Mr. Charles A. Pim (see Figure 40) is shown in Figure 43. The butyl chloride is boiled in the flask until the chlorinating chamber is full of vapour and liquid drops from the end of the reflux condenser, while a stream of dry chlorine is passed in rapidly, care being taken, however, that the butyl chloride remains in excess. During the whole operation the apparatus must stand in a good light, and on dull days ultra-violet light from a mercury lamp is used to facilitate chlorination. As fast as the higher-boiling dichloride is produced it drops back into the boiling flask, and as this is provided with an efficient fractionating column, only the lower-boiling butyl chloride can pass into the chlorinating column ; the dichlorides are thus removed by gravity from the sphere of the action of the chlorine and thus escape further chlorination. The liquid in the flask is finally fractionated and the dichlorides isolated in a pure condition.

These dichlorides are next passed over hot soda lime contained in a tube heated to 470°C as shown in Figure 42; the soda lime abstracts hydrochloric acid from the dichlorides and produces butadiene thus :—

$$\underset{\text{Butylene Dichloride.}}{CH_3CHClCH_2CH_2Cl} \xrightarrow[-2HCl]{\text{Hot Soda-lime.}} \underset{\text{Butadiene.}}{CH_2=CH-CH=CH_2}$$

The issuing butadiene is a gas, but on cooling it condenses to a colourless liquid, and so is easily separated by passing the vapour coming from the hot soda-lime through a vessel immersed in a freezing mixture. A similar method is used for making isoprene from amyl alcohol—as we will see presently.

Professor Perkin also proposes to produce butadiene from aldehyde, CH_3CHO, which is produced from alcohol merely by oxidising it—the alcohol being obtained from the starch of cereals or potatoes by ordinary fermentation with yeast. The aldehyde is treated with a dilute solution of potassium carbonate (washing soda, soda ash) whereby *aldol*, $CH_3CH(OH)CH_2CHO$, is formed. This is then reduced with nascent hydrogen and yields butylene glycol, $CH_3CH(OH)CH_2CH_2Cl.$, which is then converted into 1:3 dichlorobutane, $CH_3CHCl.CH_2CH_2Cl.$, which yields butadiene when passed over hot soda lime as above described. Alcohol at present costs about threepence per pound.

The butadiene, no matter by which of these processes it is produced, is then converted into butadiene rubber by warming with sodium in the manner previously described.

The formation of butadiene rubber is thus represented by Prof. Harries, of Kiel :—

$$\underset{\text{Butadiene.}}{\begin{matrix}CH_2=CH-CH=CH_2\\CH_2=CH-CH=CH_2\end{matrix}} \xrightarrow{\text{Sodium.}} \underset{\text{Butadiene Rubber.}}{\left(\begin{matrix}CH_2-CH=CH-CH_2\\|\qquad\qquad|\\CH_2-CH=CH-CH_2\end{matrix}\right)_x}$$

A yellowish mass is thus obtained, which is washed with alcohol or heated with steam to drive off any unchanged hydrocarbon. It can be vulcanised to produce an excellent rubber.

It will be noticed that in the two processes above described the raw materials are: *maize or potatoes*—the starch of which at present costs less than one penny a pound ; *common salt* (to produce the chlorine and sodium) ; and *lime*. The total cost of the raw materials does not exceed twopence per pound. In fact, Mr. Strange calculates that synthetic rubber could be produced at fourpence to sixpence per pound. I understand that quite recently Professor Fernbach has further developed the bacteria, so that they will ferment wood in the form of cellulose—instead of maize or potatoes—and produce a fair yield of acetone and fusel oil. This advance, however, has still to be utilised commercially—so that it remains an interesting laboratory experiment.

Instead of starting with butyl alcohol, which is the main constituent of *wine fusel oils*, but which can now be obtained in almost unlimited quantities by the fermentative processes introduced by Professor Fernbach, we can start with *iso*amyl alcohol, which is the main constituent of the fusel oils obtained in spirit manufacture from cereals or potatoes.

*Iso*amyl alcohol has the constitution $(CH_3)_2CH\ CH_2CH_2OH$. It is first converted into the chloride $(CH_3)_2CHCH_2CH_2Cl.$ by dry hydrochloric acid gas, and the monochloride thus produced is then converted into a dichloride by treating with chlorine gas in a Pim's apparatus as previously described under butyl alcohol. Three dichlorides are thus produced, namely: isopropylethyltrimethylenedichloride, $(CH_3)_2CHCHCl.CH_2Cl.$ (B.P. 142) ; gem-dimethyltrimethylene dichloride, $(CH_3)CCl.CH_2CH_2Cl.$ (B.P. 152–155) and β-methyltetramethylene dichloride, $CH_2Cl.CH\ (CH_3)\ CH_2CH_2Cl.$ (B.P. 170–172). These dichlorides when passed over hot soda-lime produce isoprene, the soda-lime extracting the elements of hydrochloric acid, thus :—

$$\underset{\text{Butylene Dichloride.}}{\begin{matrix}CH_3\\CH_3\end{matrix}\!\!>\!C-CH_2-CH_2Cl.\ (Cl.)} \xrightarrow[\text{Lime.}]{\text{Hot Soda.}} \underset{\text{Isoprene.}}{\begin{matrix}CH_3\\CH_2\end{matrix}\!\!>\!C-CH=CH_2}$$

The isoprene is then converted quantitatively into rubber by metallic sodium.

However, as amyl alcohol fusel oils are to-day quoted at one hundred and forty pounds a ton, and have a host of other useful applications, it is doubtful whether such a process would survive competition with the butyl fusel oil process which can

be produced at thirty pounds a ton, by Fernbach's new process.

It should also be noted that *isoprene* may be obtained from *acetone* in several ways. For example, Fr. Bayer & Co., of Elberfeld, propose to manufacture isoprene by condensing formaldehyde with acetone in the presence of weak alkali, to form 2-ketobutanol and other products :—$CH_3COCH_3 + CH_2O = CH_3COCH_2CH_2CH_2OH$. From this water is split off and methylene acetone is produced :—$CH_3COCH=CH_2$, and from this isoprene is produced. Dr. F. E. Matthews has also worked out methods for changing acetone into isoprene. However, these methods do not appear to be commercially remunerative.

To sum up, then, three practical methods have been devised for obtaining rubber from starch :—

(1) From Fernbach's fusel oil—consisting principally of butyl alcohol and costing about thirty pounds to forty pounds per ton; (2) from industrial alcohol through aldehyde, alcohol costing threepence per pound; (3) from fusel oils obtained from spirits—which at present cost about one hundred and forty pounds per ton.

The raw material is in every case obtained by agricultural processes. Table 10 represents the new industries and their relation to the old. (See page 44.)

Since the whole chain of industries mentioned in this Table ultimately rests upon agriculture as a basis, it would seem that a good time is coming for farmers.

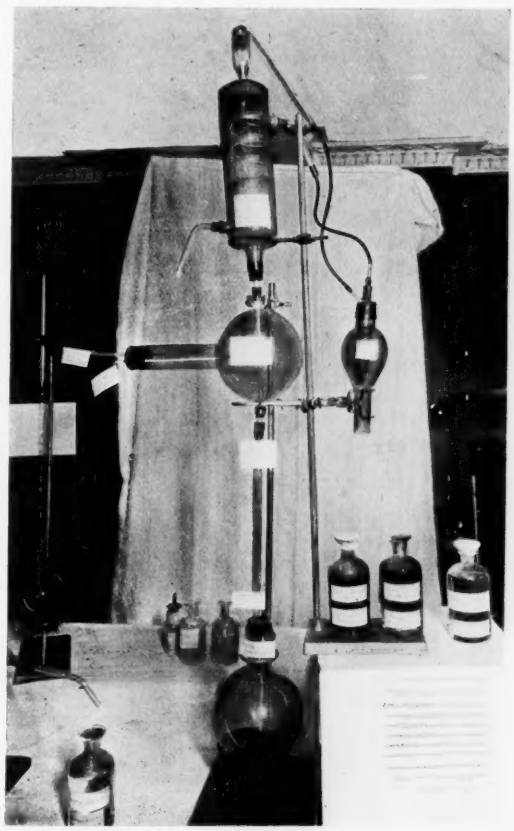


FIGURE 43.

Mr. C. A. Pim's Apparatus for the fractional distillation of butylene dichloride.

So far we have discussed the methods of producing rubber from starch, in the form of cereals or potatoes. It must not be forgotten, however, that wood could be used as a starting point for producing mashes capable of fermentation. For example, several processes are known, and are even worked on a limited scale, of converting wood into sugars, which can then be fermented much in the same way as the starch mashes referred to above. Although possible, however, it is improbable for many reasons that such processes will be able to compete with those which use starch as their starting point.

The next promising method for producing synthetic rubber starts from raw petroleum. From petroleum both butadiene and isoprene have been obtained by special "cracking" processes—for example, passing it over red hot surfaces impregnated with special "contact" substances, and, indeed, at the present time the writer is aware of a vast amount of secret research going on with this object in view.

Somewhat more promising are chemical processes; to give an example, according to one suggested process the petroleum is fractionated, and a product containing isopentane, $(CH_3)_2CH.CH_2CH_3$, is isolated. This is then treated with chlorine and a mixture of dichlorides, $C_5H_{10}Cl_2$, are obtained. These are then sent over hot soda lime, when isoprene is produced thus :—

CH_3
CH_3 > $C\,Cl.CH_2CH_2Cl.$

A dichloride from isopentane.

Soda Lime hot.

CH_3
$CH_2=C-CH=CH_2$

Isoprene.

By treating other fractions of petroleum in a similar manner not only isoprene but also butadiene and dipropylene can be obtained and converted into rubbers in the usual way by treating with sodium.

There still remains to be considered the production of rubber from turpentine oils. When these are passed under certain conditions over hot contact surfaces isoprene may be produced in quite considerable quantities, and a great many patents have been taken out for improving the yield.

The general consensus of opinion among technical chemists, however, is that the raw materials are too expensive to allow a commercially remunerative synthetic rubber to be produced from turpentine oil.

Before leaving the subject of synthetic rubber manufacture, however, I must say a few words about rubber obtained from still higher homologues of butadiene than isoprene.

First of all there is the hydrocarbon *β-γ-dimethyl-butadiene* also known as dipropylene and isopropylene. This substance is simply butadiene in which

two hydrogen atoms are replaced by two methyl groups, thus :—

$CH_2=CH-CH=CH_2$ Butadiene.

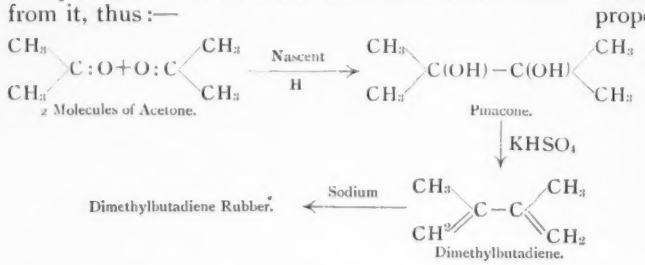
$CH_2=C(CH_3)-C(CH_3)=CH_2$ β-γ-Dimethyl butadiene, dipropylene, isopropylene.

Dimethylbutadiene is also a volatile liquid, boiling at 71°C, and can be turned into a rubber by treating with sodium, thus :—

$$\begin{matrix} CH_2=C(CH_3)-C(CH_3)=CH_2 \\ CH_2=C(CH_3)-C(CH_3)=CH_2 \\ \text{Dimethylbutadiene.} \end{matrix} \xrightarrow{\text{Sodium.}} \left(\begin{matrix} CH_2-C(CH_3)=C(CH_3)-CH_2 \\ | \qquad\qquad\qquad | \\ CH_2-C(CH_3)=C(CH_3)-CH_2 \end{matrix} \right)_x$$

Dimethylbutadiene rubber.

The rubber thus produced—a white tough leathery mass—can by vulcanisation be made to yield a beautifully elastic substance; unfortunately, however, on allowing the vulcanised product to stand in the air it turns into a sticky mass. Perhaps in the near future experiment may overcome this difficulty and the substance may yet, for special purposes, attain technical importance. Dimethylbutadiene or dipropylene is obtained from *acetone* by reducing it to pinacone by means of magnesium amalgam, and then passing the pinacone over heated potassium bisulphate, which withdraws the elements of water from it, thus :—



Dr. Fritz Hofmann, of Fr. Bayer, Elberfeld, has produced a whole series of similar rubbers, in which ethyl and even phenyl and naphthalene radicles replace the hydrogen of butadiene. So long ago as 1904, Klages and Lauk showed that phenyl isoprene, $CH_2=C(CH_3)-C(C_6H_5)=CH_2$ could be made to produce ebonite-like bodies on vulcanisation.

There is thus opened up a rich field of research in the production of these "super-rubbers" from which a veritable mine of ebonite substitutes, bone substitutes, insulators, enamels, or even hornlike artificial glasses, may in the future be manufactured, and an industry be created in these products rivalling that of the coal tar dyes—an industry which also had its origin in investigations connected with the apparently useless products of coal tar.

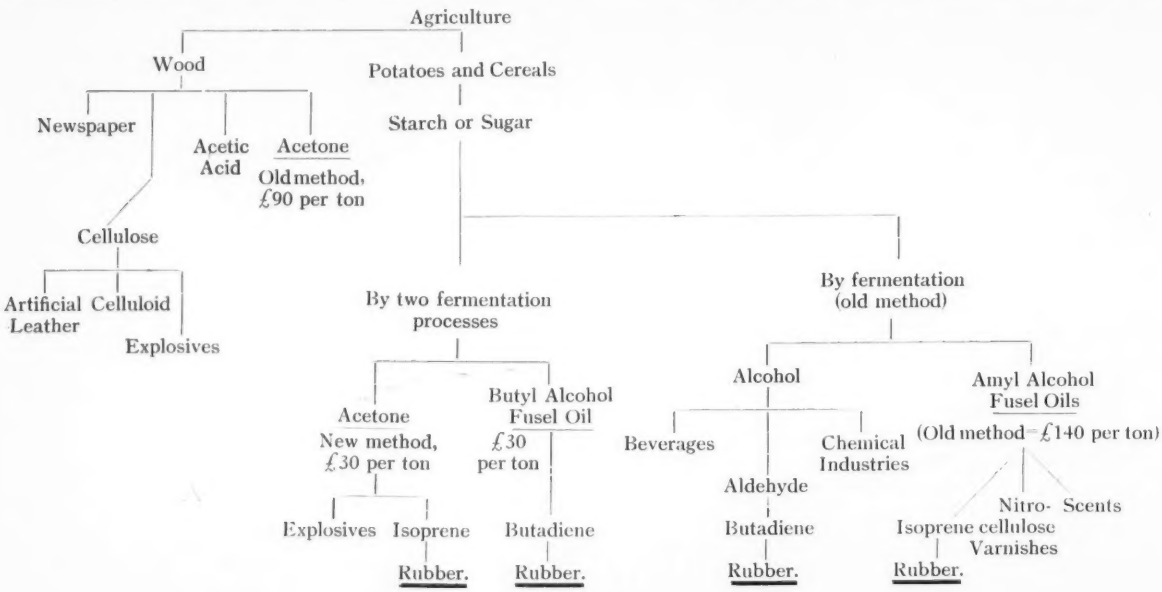


TABLE 10.

Indeed, no man can foresee the consequences of the research work now being pushed forward with such vigour in every direction in this new field of synthetic chemistry.

Let us hope, however, that these new industries will remain in Great Britain and not pass, like the coal tar dye industry, out of our hands into those of the highly-trained scientific Germans, merely because British manufacturers were too ignorant to employ proper research chemists in a chemical industry, and utterly despised the value of science applied to industry. We have had a shock in this direction, and let us hope that British manufacturers have now had this home truth driven home—that Science and Industry go hand in hand, and that pre-eminence in the one spells pre-eminence in the other.

And now a word about the attitude of the "Practical man" towards these new industries.

I cannot do better than quote a few opinions which these "practical men" have published in trade or technical journals.

In one important technical paper we read to our surprise: "Naturally produced rubber, containing as it does the greatest elasticity with the greatest strength, will ever hold the market"—a statement which may be characterised as simply untrue. Another "practical man" writes: "I observe that twenty-five thousand pounds of the subscribed money is to be devoted to experimenting with the object of producing a rubber substitute. How does that appeal to your readers as a business project?"

"It is not explained how or at what rate the proposed money is to be expended, unless it was thought wise to leave to the public's imagination the rapidity with which laboratories can dissolve gold." The gentleman is, apparently, supremely unconscious that on the basis of research work alone vast chemical firms have in Germany come into existence which pay dividends of between twenty and thirty per cent., and that research work in industrial chemistry is probably the most paying investment that it is possible to make. On research alone some of the large German firms spend thousands upon thousands of pounds annually—one dye factory alone maintaining a huge scientific library and no less than three hundred university-trained chemists—and as a result they dominate the world's markets!

However, the following luminous extract, gravely printed in a financial journal, fairly reaches the limit:—

"Is it not entirely a question of trying to make bricks without straw, to try and make rubber out of rubbish?

"People have tried to make gold and diamonds, and in these cases the reward of anyone successful would be enormous. Are they more likely to be able to make rubber, the real thing I mean, with all the live properties in it? As well try to make an egg which will hatch out."

FIGURE 45.

Fermentation Vats now being erected at Rainham, Essex, by the Synthetic Products Company for the production of fusel oil on the commercial scale.

However absurd this letter appears to the trained scientific man, it fairly accurately voices the opinions of a great many people connected with the rubber trade—as many personal conversations have convinced me.

It is quite a common opinion that rubber is "alive" in a way, with a special "nerve," and, therefore, like other living matter, cannot be synthesised.

As a matter of fact, however, rubber is simply a colloidal chemical compound or mixture of chemical compounds, and all its properties, both chemical and physical, are all explicable by ordinary chemical or physical explanations without having resort to "vital forces" or anything of a like nature. It is only bare justice to these practical men to say that I have not yet heard any one of them assert that rubber has a "soul" as well as "vital" properties.

Many other "practical" men consider that synthetic rubber must necessarily prove inferior to "natural" rubber because "natural" things are always better than "artificial" and that "Nature" is "perfect." These individuals have evidently some characteristics in common with the "back-to-nature" cranks, who wish us to live in trees and do without baths merely because our simian ancestors had the misfortune to be compelled to undergo these hardships.

At the back of the minds of this variety of "practical" men lies, no doubt,

FIGURE 44.

Mr. Harold Davies, Assistant to Professor W. H. Perkin, distilling isoprene for making synthetic rubber.

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the thought that "Nature" has in some mysterious way a special interest, possibly of a financial kind, in enabling plants to produce a material good for making motor-car tyres, and that, therefore, the chemical compound caoutchouc, prepared from the juices of certain tropical trees, must necessarily be superior to the same chemical compound prepared from petroleum or starch or any other material of like nature. As a matter of fact scientific botanists have unanimously come to the conclusion that "Nature" did not have motor-car tyres in view when she evolved these rubber-producing juices. She was probably trying to perfect a means of protecting such trees against boring insects. When a puncture was made by an insect in the bark of a tree the sap was exuded and the insect was overwhelmed, and so by natural selection the highly developed rubber trees of to-day were gradually evolved in the forests of Brazil and of Africa. Other views of latex formation are that the rubber is a reserve food material for the plant, or is an excretory material of the plant's metabolism.

The fact that the coagulated parts of the juice can also serve to make motor-car tyres is a perfectly accidental circumstance, which so far from being beneficial to rubber trees may probably lead to their extinction—of the wild varieties at any rate—if the destruction of the rubber forests continues at its present rate.

In fact, the synthetic chemist, who is solely directing his energies to producing a substance suitable for making good motor-car tyres or waterproofing material has obviously a great advantage over Dame Nature, who has entirely different objects in view, and there can be little doubt who will in the long run produce the superior product for the uses of industry.

Indeed, the prejudice against "artificial" rubber, as such, is about as reasonable as a prejudice against "artificial iron" or "artificial copper." The production of iron or copper from the earthy matters known as their ores by chemical processes is perfectly analogous to the production of rubber from substances like starch or petroleum by chemical processes; and in the same way that the "artificial" iron or copper of to-day is far superior to the "natural" iron and copper, still to be found in various parts of the world, for the purpose of making engines or tools, so also will the "artificial" rubber of fifty years hence be superior to the "natural" rubber of that day for industrial purposes. Special artificial rubbers will no doubt made be for special purposes, just as special kinds of steel are made to-day for special kinds of work.

That "artificial" rubber will at a blow displace natural rubber is highly unlikely—even if the process of manufacture is perfected. The substitution of the one for the other will probably be a slow process, and may never reach completion—so vast is the demand for raw rubber and so limited are the supplies of raw material. All that can be said at present is that chemists have succeeded in producing synthetic rubber, and that no scientific reason stands in the way of them putting it on the market.

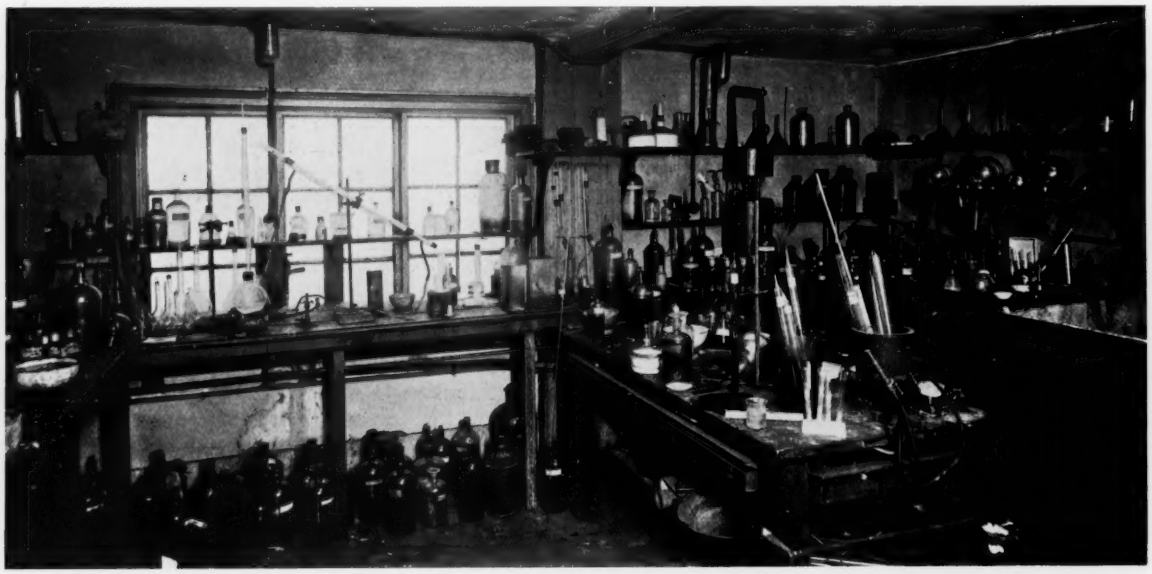

FIGURE 46.

A corner in Messrs. Strange & Graham's Laboratory showing tubes of isoprene polymerising to rubber.

A DETAIL IN THE PROTECTIVE COLOURATION OF BUTTERFLIES.

(Read before the Ashmolean Society of Oxford.)

By THE REV. F. BENNETT, M.A., OXON.

I DO not know whether the particular detail of protective colouration to which I wish to draw attention has been already described in any of the multitudinous works dealing with that fascinating subject; but, if it has, I will refrain from exclaiming with the ancient author: "May they perish who have made our *observations* before us!"

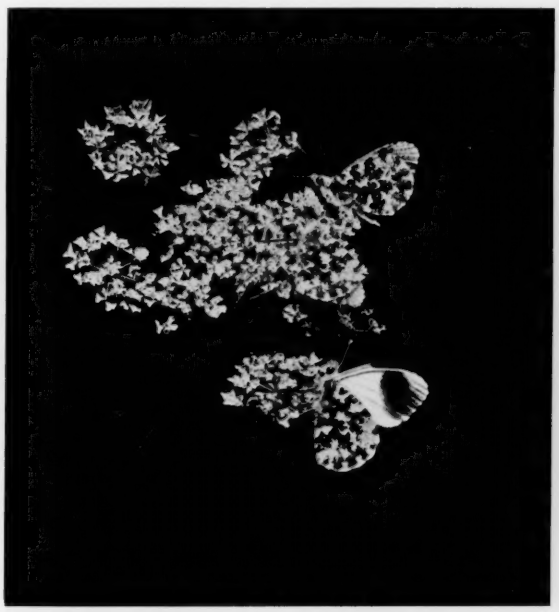

FIGURE 47.
Orange Tip Butterflies on Wild Chervil.

FIGURE 48.
Bath White Butterflies.

In the case of many of our English butterflies, when one of them alights, and intends, not merely to sun himself or display his beauties to an admiring sweetheart, but to rest for some time, he first folds his wings together closely back to back, and then draws his fore wings downwards in such a manner that they are, as completely as possible, covered by the hind wings; and it is obvious to any observer that in very many cases the underside of the hind wings is the part so coloured in various ways as to resemble the surroundings and thus conceal the creature from its enemies.

I say "as completely as possible"; for the difference in the shapes of the fore wings and hind wings prevents this covering from being quite complete. In almost all cases the hind wing is rounded, while the fore wing is more or less triangular in shape and ends in a point, and thus the tip of the fore wing remains uncovered and visible.

Now the beautiful detail which I propose to illustrate is this:—that the uncovered portion of the underside of the fore wing repeats in a great number of instances the pattern and colouring of the under surface of the hind wing and thus carries out to perfection the concealment; while the remainder of the under-surface of the fore wing covered when at rest by the hind wing, has often quite different colouring and is in many cases of most brilliant and conspicuous hues.

As I first observed this detail in the "Orange Tip" (I prefer the ordinary English names to the scientific ones, as each butterfly has such a number of systematic synonyms), I will give that charming little herald of spring the first place in the illustrations (see Figure 47), though it is not perhaps the best of them.

No one will, after looking at the picture, doubt for

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a moment the use of the peculiar pattern on the underside of the hind wing. The butterfly is settled on an umbel of wild chervil and any one who wants a specimen of an Orange Tip has only to wait in a lane full of that plant and he will soon find one coming along, if it be May or June, though he may look in vain for one in the adjoining fields.

The resemblance is so complete that the butterfly in the midst of the umbel can hardly be discovered at all, and if the photograph could have been done in colours, the concealment would only have been more completely shown; the white parts of the wing representing the flowers, and the green parts representing the stalks, involucres and other green parts of the plant as well as the background of grass or hedge in the distance. The conspicuousness of the specimen whose wings are not drawn together proves the point to perfection.

Now the pattern (we might call it *the design*) on the hind wing which so completely conceals the resting Orange Tip is, it will be seen, continued at the tip of the fore wing and this continuation of the pattern is precisely outlined by the very curve which the end of the hind wing makes. They fit exactly! But the orange spot is completely concealed.

But there is more than this, for it will be observed that the front margin and even the thin, sharp edge of the fore wings (this edge being often somewhat rounded) have markings of the same type, so that, looked at *in front*, the protective resemblance to the flower is continued, in place of a white line which would otherwise appear and be dangerous—so minute are Nature's details in this matter.

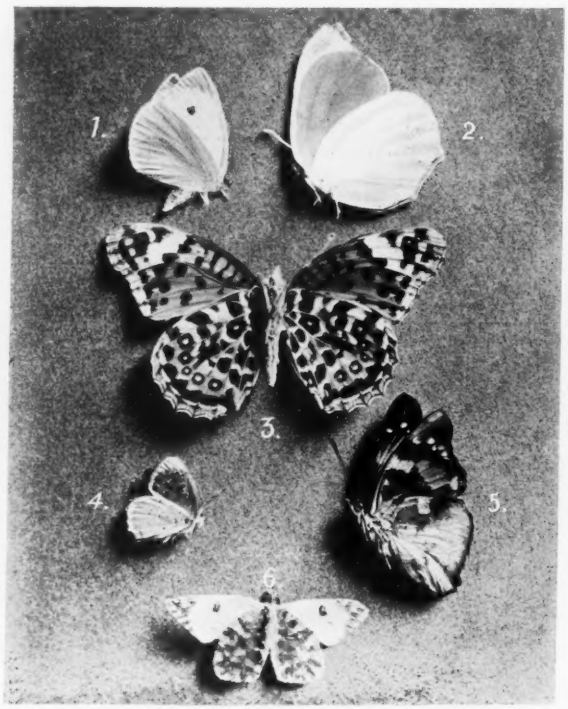

FIGURE 49.

1. Large Cabbage White.
2. South European Brimstone.
3. Foreign Species.
4. Small Copper.
5. Foreign Species.
6. Foreign Orange Tip.

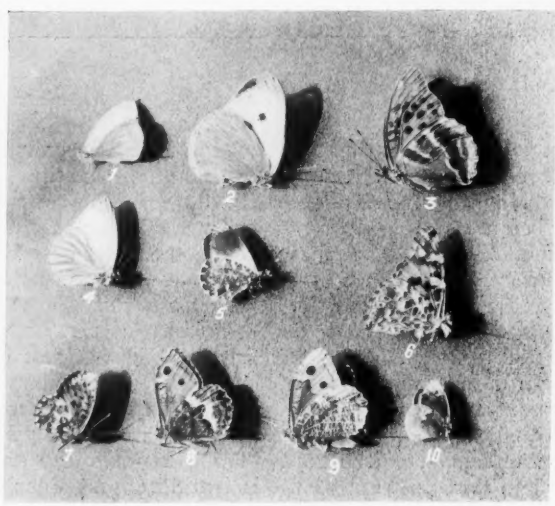

FIGURE 50.

1 & 4. Green-veined White.
2. Small Cabbage White.
3. Silver-washed Fritillary.
5. Orange Tip.
6. Painted Lady.
7. Pearl-bordered Fritillary.
8 & 9. Grayling.
10. Small Heath.

But there is yet even more. It will be seen on examination that the pattern on the tip of the fore wing is somewhat run into lines (as may be seen in Figure 50, number 5). This repeats a tendency to the same thing at the margin of the hind wing: and it thus imitates in connection with the background of green, and just at the right place, the appearance which the *edges* of the umbel present.

The completeness and exactness of the continuation of the pattern are even more clearly shown in the butterfly Figure 49, number 6, a foreign relative, I think, of our Orange Tip. In this the imitation of the pattern on the hind wings is much more exact, as will be easily seen.

The *economy* of Nature is wonderfully illustrated in these cases, since there is precisely as much of the needed pattern on the fore wings and no more—the curves fitting so truly—of the hind wing and of the fore wing design.

Just the same sort of pattern and its repetition are seen in the "Bath White," Figure 48.

A brief review of the illustrations will sufficiently demonstrate the use of this arrangement of colour and markings.

Figure 49, number 1, and Figure 50, number 2, show the large and small Cabbage Whites. In both the greenish-yellow of the hind wing is repeated at the tip of the fore wing. The colour is close to that of the cabbage flower, but it more closely still resembles that of a dead piece of cabbage leaf, which, when faded, takes exactly this colour.

It may be noticed that a "small white" will sometimes place itself *sideways*, so that its wings lie flat on the leaf. The same is true of "Meadow Browns," which sometimes thus place themselves on the ground. Such a position would aid in the concealment and (in the absence of any other explanation of this curious custom) would seem to be adopted for that reason.

Figure 49, number 2, is a South European form of the "Brimstone" and the greenish-yellow of the hind wing is repeated at the tip and along the front margin of the fore wing, while the folding conceals a brilliant patch of orange. This repetition along the front margin would be useful while the folding of the fore wing behind the hind wing was in progress, or was incomplete.

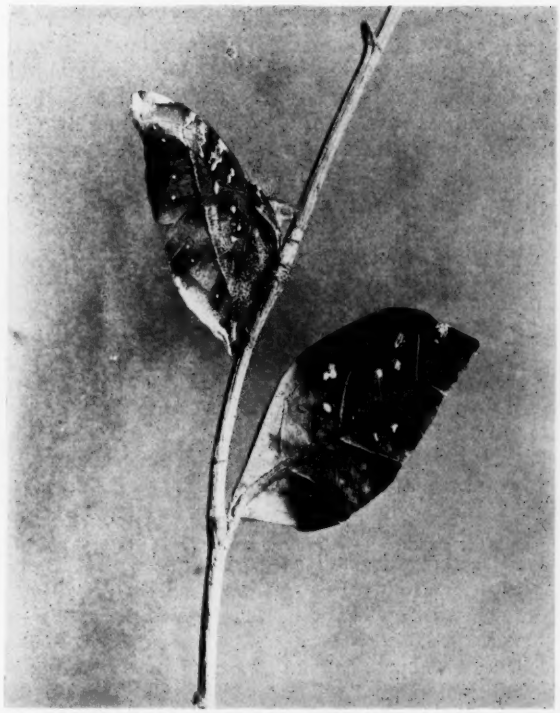

FIGURE 51. Leaf Butterfly.

Figure 49, number 3, is a foreign butterfly in which the silver spots and olive green of the underside of the hind wings are repeated at the tip of the fore wing, whilst the rest of the fore wing, concealed when at rest, is of a bright red-brick colour with black spots, and a conspicuous white bar.

Figure 49, number 4, is the "Small Copper," in which the grey of the hind wing is continued at the tip of the fore wing, and the brilliant colour and spots hidden by the folding over.

Figure 49, number 5: Underside of a foreign butterfly. The coloration of the hind wing, a dusky brown, is repeated

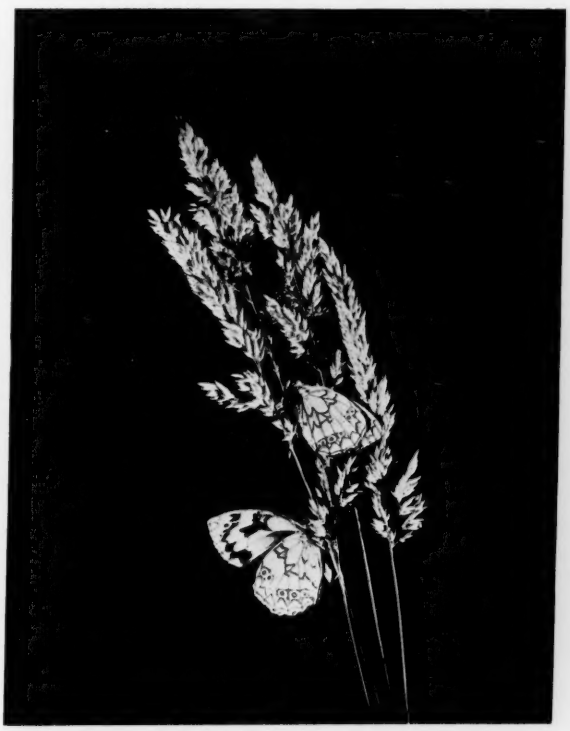

FIGURE 52.
Marbled White Butterflies on dead panicles of grass.

FIGURE 53.
Leaf Butterfly, *Kallima*.

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at the tip, and a brilliant yellow bar concealed.

Figure 50, numbers 1 and 4, are "Green-veined whites." It is well known that these vary very much, so that they have been divided by some authors into several species, and the curious thing is that, as the colours and the markings of the hind wing vary, so precisely do the colours and marking vary at the tip of the fore wing.

Figure 50, number 3, is the "Silver-washed Fritillary," in which the green of the hind wings is repeated at the tip with sometimes a little of the silver. In other fritillaries, more or less of the same arrangement will be found and in the "Pearl-bordered Fritillary" (see Figure 50, number 7), the brick red patches which are on the hind wing, are more or less repeated, with part of the paler yellow at the tip of the fore wing and only there. I do not know what this red brick may represent, but it is evident that to have a patch of a different colour at the tip of the fore wing would render the creature much more conspicuous.

Figure 50, number 6, is the "Painted Lady" in which the brown and grey of the fore wings are repeated at the tip of the fore wing, while the brilliant pink and yellow are concealed.

Figure 50, numbers 8 and 9, are two specimens of the "Grayling" or "Rock-eyed Underwing." The markings of the hind wing vary a good deal and in exactly the same manner do the markings of the fore wing vary to correspond, both at the tip and along the front margin.

Figure 50, number 10, is the common little butterfly variously called "Small Heath" and "Least Meadow Brown." In this, when closed, the brown and grey are repeated at the tip, while the yellow and orange and the eye spot of the fore wing are concealed.

Figure 52 is the "Marbled White" in which the pale and thin-lined pattern of the hind wing is repeated at the tip of the fore wing, while the darker colouring of the fore wing is concealed. This is more obvious in the American form which has a brown lined pattern on the hind wing exactly repeated at the tip of the fore wing. I do not know what the markings in the American species may represent, but it may not be a wild conjecture that the object of the pattern in the English butterfly is indicated by the surroundings which I have given it, and that it conceals the creature by imitating the dead panicles of grass which abound in those dry places near woods where the butterfly is so often to be found, and on which it frequently settles.

We do not see the full force of any argument till we look at it (so to speak) from the opposite side; and this detail in protective colouration is clearly brought out by the cases where it is not needed. Contrast, for example, the underside of the wings of the "Comma," "Large Tortoise-shell," "Peacock," where the protective colouring is spread over the whole of *both* hind wings, with the repetition of the hind wing pattern in "Small Tortoise-shell," "Red Admiral," and so on.

It is curious that in *Anosia menippe* Hübner—a butterfly which is now sometimes caught in England and which is said to be protected by a nasty taste—the paler colour of the hind wings is repeated in a patch at the tip of the forewings, while the colour of the rest of the fore wings resembles that on the upper surface. The detail seems to indicate that the bright brownish-yellow may not in these cases be *warning* as had been supposed. On that supposition it would seem difficult to find a reason (and a reason *must* exist) for this curious bit of repetition.

Figures 53 & 51 are two species of the leaf butterflies whose likeness to dead leaves is now so familiar to us all. These, of course, do not fold the fore wing behind the hind wing, and there is, therefore, no reason for any repetition of the hind wing pattern. The tip merely displays a little imitation of a fungus.

The head of the insect is placed between the wings and hidden, when it is at rest. This puts out of sight the conspicuous eye, which would perhaps tell a tale, so complete are the arrangements for concealment.

An interesting point here occurs: most dead leaves hang down; do the Kallimas take that position or do the leaves of the trees on which they rest retain the upright position when dead? I have not seen this noticed by the authors on the subject.

The Nyctalemon Moth of the Andaman islands evidently represents a dead leaf, as it has an imitation of a midrib throwing an imitation shadow on one side, and has also a tail to represent the stalk. But most moths appear to rely on the upper surface of their wings for concealment. Many of them, as the so-called "Underwings," have their brilliant colours on the upper surface of the hind wings and conceal these, when they are resting, with the fore wings, which are protectively coloured. This no doubt applies to some butterflies whose wings are coloured in the same way.

The "Skippers" form a group half-way between the Moths and the Butterflies. Our "Dingy Skipper" is said to rest with the wings folded over its back in the exact position of a noctuid. Now the "Dingy Skipper" shows no sign of any repetition at the tip of the fore wing of any special colour on the hind wing: but the "Large" and the "Small" Skippers both show the usual repetition of the hind wing colouring. How *they* rest I am not certain.

Every one will, I am sure, agree that sufficient proof has been given of the existence of this curious and minute arrangement of Nature for the protection of these little creatures; but it is in all such cases to be noticed that there is often some little imperfection in the work of protection. It seems as if Nature in Evolution was sometimes actuated by two or more contradictory plans, which she has to harmonize as best she can. There is the tendency to some protective resemblance, but there is also the tendency to brilliance of colour or design for the purpose of recognition by or attraction of the opposite sex; and, lastly, there seems to be a real tendency to develop colour in special places, as, for example, along the nervures of Lepidoptera, as in the "Green-veined

White," "Black-veined White," and so on, a tendency which is also, no doubt, responsible for the frequent coincidence of markings on both sides of the wings, as in the "Brimstone," "Clouded Yellow," "Apollo," and so on.

Such tendencies are obviously opposing ones; and one is often lost in admiration at the wonderful methods by which Nature has reconciled them, often producing the most perfect protection and at the same time the greatest beauty. It is conceivable also that in such a case as that of *Danais chrysippus* the upper side of the wings may have warning colours while the under side, where the yellow of the hind wings is repeated at the tip of the fore wings, as in *Anosia menippe*, may be protective, to guard against inexperienced enemies who do not know that they are unpalatable for eating, and so would kill or injure them in mistake, just as cats kill innumerable shrews which afterwards they will not eat.

This detail in colouring shows with what minuteness Nature carries out the plan of protective colouration and resemblance, and how small a piece of detail gives some advantage in the struggle for escape; for otherwise this little bit of colouring would not have continued. In further illustration of the minuteness observe the delicate imitation of a tear in the wing of *Kallima* (see Figure 53). Only with a magnifying glass can one see that the tear is not real, and that the wing is perfect. The effect is produced by alternate black and white markings.

The success of the protective colouring is frequently forced on the attention of the butterfly hunter, who finds that the insect he has been pursuing has disappeared from his view though he knows and sees, just too late, that it has been all the while within a very small plot of ground.

There is also another point of view which I have not seen brought forward, as to the success of this sort of protection. It is this:—That an animal *has no time to waste* in examining objects which at closer quarters might (though a little *suspicious*) turn out to be really twigs or leaves; and thus a very imperfect resemblance (to *our* eyes who have plenty of leisure for the examination) would often be sufficient, and would be preserved till in process of time a more and more perfect resemblance was evolved. If one watches a bird supplying its ravenous nestlings one can easily see that it has to do the work at full speed.

If we sometimes thus placed ourselves in the position of animals, and by imagination "identified our minds" (in E. A. Poe's phrase) with theirs for awhile, we should very often comprehend Nature better and discover more of her secrets.

CORRESPONDENCE.

A PHYSICAL PHENOMENON.

To the Editors of "KNOWLEDGE."

SIRS,—The enclosed Note on a physical phenomenon which was observed at Maymyo towards the end of last May will, it is believed, prove of special interest to your readers. The author of the note is Mr. H. M. S. Mathews, C.S.I., Commissioner of Settlements and Land Records, Burma, and is the outcome of his personal experience of the occurrence.

Maymyo is a hill station, the summer headquarters of the Government of Burma. Its geographical position is 22° 1′ N. and L 96° 29′ E.; and its height above mean sea level is three-thousand seven hundred and eighty feet. The Moon was full on 31st May at $5^h\ 59^m\ 36^s$ a.m., when its R.A. was 17° and Dec. 27° S.; so that the phenomenon would have been visible when the Moon was in the E.S.E., and about 20° to 40° in altitude.

The special points about the particular phenomenon are: *first*, that the luminous area behind the shadow of the head was accompanied by an entirely distinct circle of light some distance away from the luminous area, the feet standing on the circumference of this circle; *second*, that the phenomenon was seen by the light of the Moon, not the Sun.

The phenomenon is believed to be what is known as Anthelia or "Glories," the following description of which is taken from an Encyclopedia, *viz.*: "*Anthelia* are luminous rings seen by an observer on a cloud or fog which lies opposite to the Sun. They are only seen when sunshine and cloud, or fog, occur at the same time. They appear when, from an elevated position, the shadow of an observer is projected by the Sun on a cloud or fog; he sees the head encircled by a glory or luminous ring, diminishing in brightness as it leaves the head as a centre. A phenomenon substantially similar to the anthelia occurs when, the Sun being near the horizon, the observer sees an aureola surrounding the shadow of his head cast upon grass or corn moistened with dew."

Some of your readers have perhaps witnessed similar phenomena elsewhere, and any information that they can furnish on the subject would be very acceptable.

RANGOON (BURMA). J. C. CLANCEY.

NOTE.—On the moonlit nights of the last week of May, 1912, some days after the earthquake shock of the 23rd May, a phenomenon, believed to be that known as Anthelia or Glories, but novel to the observers, was seen at Maymyo.

There were heavy dews at the time and as soon as it was sufficiently dark for the moon to cast distinct shadows the observer noticed that on the dewy short grass of the lawn a patch of light appeared round the shadow of the head, while there was also an outer circle of light with the head shadow as a centre and with a radius of the length of the observer's shadow.

The patch of light or inner halo had no definite outline, but was brightest alongside the shadow of the head and was distinct over a space with about twice the diameter of the head shadow.

The illuminated band of the outer halo averaged perhaps a foot in width. It was narrower when the Moon was high, and was then bright and distinct throughout its circumference.

Both halos were white, and it was noticed that the head halo and outer halo attached to each person's shadow was visible to that person only. Another person looking over the first person's shoulder could not see that person's halo, though he could at the same time see his own distinctly.

At the time of the phenomenon there appeared to be nothing unusual in the appearance of the Moon or sky. The former was bright and the latter clear.

The phenomenon was first noticed on Tuesday, 28th May, and was observed for several nights. On the night of Friday, 31st May, at 10 p.m., it was seen by a number of persons and was then very distinct.

MAYMYO. H. M. S. M.

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EXPERIMENTS ON LIQUID DROPS, GLOBULES, AND COLUMNS.

By CHAS. R. DARLING, A.R.C.Sc.I., F.I.C.

I.

BEFORE the advent of the nineteenth century, the number of liquids available for scientific investigation was limited to water, alcohol and other products of fermentation, naturally-occurring oils, and a few obtained by chemical means. Now, thanks to the advances made in organic chemistry, the number of available liquids has been greatly increased; but although the chemical properties of the newer liquids are well known, very scanty attention has been paid to their physical properties. Hence the liquids used in the ensuing experiments, although familiar to the chemist, would probably be designated "rare" liquids by the physicist, because their constants do not appear in ordinary physical tables. The present articles will be devoted to a description of some of the remarkable physical properties of certain organic liquids, which have been investigated by the writer during the past two years, more especially with regard to the formation of drops, spheres, and columns; and the strange movements of globules on a water surface.

THE FORMATION OF DROPS AND SPHERES.

In the issue of "KNOWLEDGE" for January, 1911, the author described an experiment for producing automatically large drops of aniline under water, the process being sufficiently slow to enable the details of formation to be seen with the naked eye. The experiment was based on the fact that aniline is denser or less dense than water at different temperatures, and from the standpoint of studying the beautiful changes in shape undergone by parting drops, suffered from the defect that the formation was not under control. In order to produce a drop which may be made to enlarge to considerable dimensions, and to break at will, it is necessary to run the liquid used into water from a vessel controlled by a tap, and to employ a liquid only slightly denser than water at the prevailing temperature. After many trials, the author has found that the liquid *orthotoluidine* is in every way suitable for the purpose. As sold commercially, this liquid has a deep red colour: is insoluble in water; and at 24°C has exactly the same density as water at 24°. Above this temperature orthotoluidine is lighter than water, whilst below 24° it is heavier; and as the equi-density temperature is near to that of the atmosphere in a room, the experiment may be conducted with the minimum of trouble.

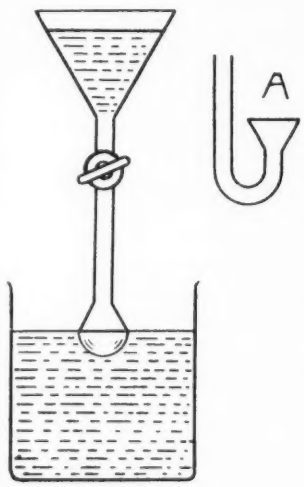

FIGURE 54.

Apparatus for forming large, controlled drops of liquids.

The apparatus requisite for the complete study of drops under control is extremely simple, and is sketched in Figure 54. A funnel, furnished with a tap, and having the stem widened at the extremity to a diameter of three or four centimetres, is arranged so as just to touch the surface of water contained in a flat-sided glass vessel about fifteen centimetres high, 12·5 centimetres wide, and 7·5 centimetres deep—exact dimensions being of no importance. The water in the vessel should be at a temperature of about 20°C., and orthotoluidine allowed to flow in slowly from the tap. A large drop then gradually forms at the end of the stem of the funnel, and by closing the tap at any time the outline of the drop may be examined at leisure. Control ceases when the constricted neck becomes narrow, and the drop then slowly breaks away, a secondary drop, as usual, being formed from the neck itself. The accompanying Figures—55 to 61—from photographs by the writer and Mr. B. Abel, show several stages in the formation of a drop of orthotoluidine, controlled as described. Figures 60 and 61 are specially interesting as showing the recoil after the partition of the drop, both the portion clinging to the stem and the separated drop being flattened; and the secondary drop, which is seen elongated in Figure 60, is seen to have recoiled in Figure 61. An exposure of approximately one-tenth of a second was given, the vessel being illuminated by an arc-lamp. It is easy, by this method, to obtain drops three or four centimetres in diameter, if the instructions given above be carefully followed.

An interesting modification of the experiment is the production of inverted or rising drops, which may be accomplished by bending the stem of the funnel into a parallel branch, as shown in Figure 62. The widened end is then immersed in water at about 35°C to a depth of three inches, and the tap of the funnel opened so as to allow the orthotoluidine to flow slowly. As the liquid is warmed to a higher temperature than 24°C in passing through the stem, it becomes of less density than the surrounding water; and on escaping the drops, therefore, rise to the surface. The general

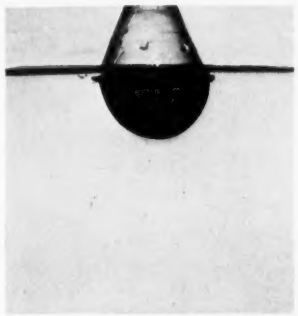

FIGURE 55.

FIGURE 56.

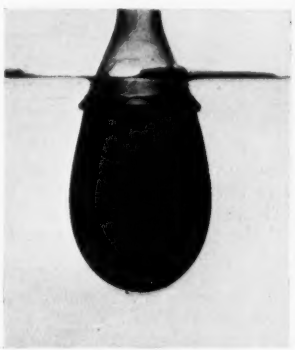

FIGURE 57.

FIGURE 58.

shape of inverted drops resembles that of falling drops, the neck, as usual, giving rise to a secondary small drop.

The production of spheres of liquids demands equality of density between the liquid and its surroundings. Formerly, Plateau's method was followed, in which spheres of oil were formed in a mixture of alcohol and water brought by trial to the same density as the oil—a somewhat troublesome proceeding. By carrying out the following instructions, spheres of liquid, of any desired size, may easily be obtained:—A flat-sided glass vessel, about eighteen centimetres (seven inches) high, is filled with water at 23°C to a height of about twelve centimetres. The correct temperature is secured by adding warm water to tap water and mixing until a thermometer shows 23°C. By the aid of a pipette a five per cent. solution of common salt in water is discharged at the bottom of the vessel, to a depth of about two centimetres, this layer preventing the sphere, when formed, from sinking to the bottom when the temperature falls. Orthotoluidine is now allowed to flow gradually into the water from a tube of one centimetre diameter, the end of which, to commence with, is placed about two centimetres distant from the surface of the layer of salt solution, but is afterwards raised gently as the sphere grows in size. In this way spheres two hundred cubic centimetres or more in volume may be formed; and, by raising the delivery-tube rapidly, the attached sphere may be separated, and will remain floating in the liquid.

The photographs shown in Figures 62 and 63 illustrate the mode of formation and the appearance of the detached sphere. In the experiment depicted the orthotoluidine was run from a burette, with a view to measuring the volume of the sphere, which in this case was one hundred cubic centimetres.

Professor C. V. Boys, F.R.S., has suggested a modification of the procedure which dispenses with the necessity of warming the water. After placing the layer of five per cent. salt solution at the bottom of the vessel, the pipette is again filled, and the salt solution discharged, in diminishing quantities, from the bottom layer upwards to within about two centimetres of the surface. The orthotoluidine is then allowed to flow into the centre of the vessel from a tube bent so as to discharge laterally; and the sphere formed will then float or sink until it finds a layer equal in density, in which it will remain at rest. It is necessary, in this case, to exercise care in grading the density of the water from bottom to top by discharging the salt solution slowly, and gradually rais-

FIGURE 59.

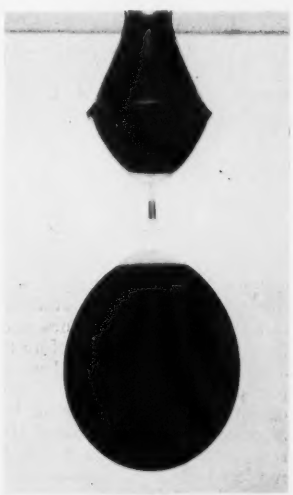

FIGURE 60.

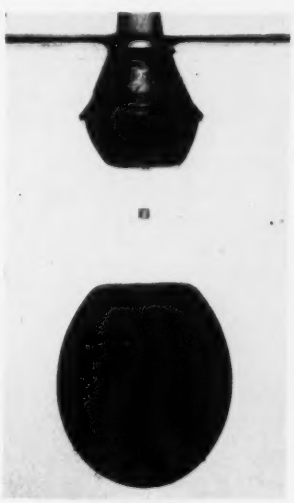

FIGURE 61.

FIGURES 55 TO 61. Seven stages in the formation of a large drop of orthotoluidine.

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ing the pipette.

It may be mentioned here that certain other liquids may be used instead of orthotoluidine; for example, anisol produces spheres when run into water at 15°C. But the beautiful colour of orthotoluidine, combined with its insolubility in water, and the absence of other objectionable features, renders this liquid more suitable than any other, either for producing controlled drops or spheres. It is, moreover, relatively a cheap liquid, and should be welcomed by all who are interested in this fascinating branch of physics, as it enables phenomena, formerly difficult and troublesome to observe, to be demonstrated in the simplest manner.

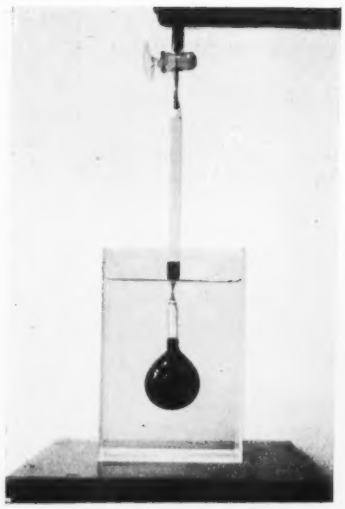

FIGURE 62. Forming a sphere of orthotoluidine.

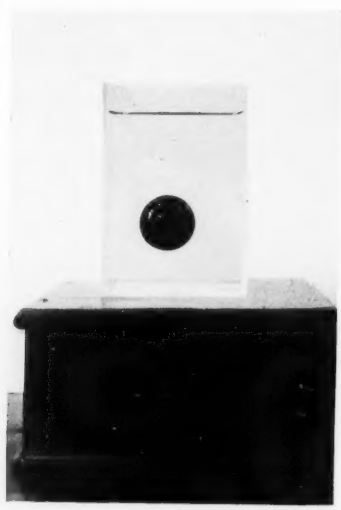

FIGURE 63. The detached sphere floating under water.

COLOURS AND THEIR CHANGES AT SUNSET ON A TROPICAL ISLAND.

By MAXWELL HALL, M.A., F.R.A.S.

Jamaican Government Meteorologist.

IN connection with the researches into the constitution of the upper regions of the atmosphere, the following notes of the colours and their changes usually seen during the first part of the year at the Kempshot Observatory, Jamaica, may prove to be useful. The colours and their changes are best seen from January to April, before the summer heat causes great ascensional movements of vapour, and before there are many particles of water in the air, which give rise to the gorgeous colours seen in the autumnal months; the steadiness of the air throughout the nights of the early part of the year is very remarkable, so much so that even stellar photometry is rendered easy and pleasant work. The latitude of the observatory is 18° 25′ north; the elevation is 1773 feet; the mean temperature from January to April is 71°; the dew-point is 65°; so that the elastic force of aqueous vapour is 0·62 inch, and the humidity 81. The position of the observatory on a range of hills commands a view round the horizon; and the hills and country round about it are clothed with thick vegetation, so that there is but little dust in the air. Under these favourable circumstances notes were made which have been condensed into the following.

Ten minutes before sunset a pink band appears on the eastern horizon: it can usually be traced all round the horizon; but it soon disappears except in the eastern half, where it grows stronger in colour and rises up from the horizon as though on pivots at the north and south points. Underneath it a dark band of a leaden blue colour appears.

At sunset this dark band is about 1½° broad; and the pink band resting on it is about 4½° broad.

Five minutes after sunset a faint pink glow, which has spread rapidly upwards from the pink band, reaches the zenith. And looking above the western horizon where the sun went down, there is a large patch of white light; its boundaries can hardly be defined, but they give the idea of an equilateral triangle, whose sides are about 45°, its base being parallel to and somewhat above the horizon. Of course, this white light and the pink glow are easily seen by contrast with the blue and bluish-violet of the remaining parts of the sky.

Ten minutes after sunset the dark blue band, still resting on the eastern horizon, is 4° or 5° broad, and is now at its darkest; it tapers off gradually to the north and south points of the horizon. The pink band resting upon it is now 15° broad, and similarly tapers off. The pink glow has reached the white patch in the west, and begins to replace it.

Fifteen minutes after sunset the dark band is 6½° broad, and begins to fade away in grey colour. The pink band has gone. The pink glow has entirely crossed over to the west, where it is now at its strongest somewhat below the top of the former white patch.

Twenty minutes after sunset the pink glow in the west, having approached the horizon, disappears.

Thirty-five to forty minutes after sunset the colours of the spectrum are best seen in the sky to the west, all parallel to the horizon; red on the horizon, and indigo or violet 25° above. This completes the colour-changes, the subject matter of this article; but the following notes are interesting and may be added.

Fifty to sixty minutes after sunset the zodiacal light appears about 20° or 25° above the western horizon.

Seventy-three to seventy-six minutes after sunset, the band of twilight along the western horizon, or the twilight arc, as it is called, coincides more or less with the base of the zodiacal light, which makes it necessary to discriminate between them in ascertaining the greatest breadth of the zodiacal light near the horizon and the greatest duration of twilight.

The angular measures referred to above were taken by a sextant from which the telescope had been removed. The general correctness of the whole was proved by frequently watching the colours and their changes at sunrise, when the whole sequence of phenomena was repeated, but, of course, in a reverse order.

On the plains near Kingston, Jamaica, there is much dust in the air near the ground, and the phenomena are not for the most part so well seen; but in the early mornings I have there seen the dark blue band in the west as distinct or even more distinct than at the observatory.

It would appear that the surface which reflects the faint pink glow is about fifteen miles above the surface of the earth; but it would be advisable to know how far these phenomena have been observed in other uniform climates before attempting their explanation.

SCINTILLATIONS.

By E. MARSDEN.

Lecturer in Physics, University of Manchester.

IT is well known that there are three principal types of radiation from radioactive substances designated α, β and γ. The first of these types, the α rays, or α particles, are single atoms of helium carrying a double elementary positive charge and moving initially with a velocity of the order 2×10^9 centimetres per second or one fifteenth the velocity of light. Different radioactive products emit α particles of different speeds but the speed is characteristic of the product. The α particles are very easily absorbed by material substances, the swiftest known, those from Thorium C, being completely absorbed by 8·6 centimetres of air and the slowest known, those of Uranium I, only penetrating 2·5 centimetres of air at atmospheric pressure.

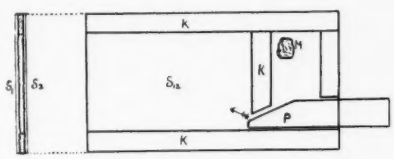

FIGURE 64.

The second type of radiation, the β rays, are known to consist of electrons or isolated elementary negative electric charges. They travel with enormous velocities varying for different products, and also for the same product, up to as much as 0·998 of the velocity of light. The β rays are not so easily stopped as the α rays, travelling on the average about one metre in air before they are stopped.

The third type of radiation, the γ rays, differ from the two preceding types in that they appear to be electrically uncharged. They are similar to very penetrating Röntgen rays, but their exact nature constitutes the battling ground of many rival theorists, for the problem appears also to involve that of the fundamental constitution of light waves. The γ rays seem to be closely connected with the β rays in much the same way as Röntgen rays are connected with cathode rays. All radioactive products which emit γ rays also give β rays, although certain products are known which emit β rays without any appreciable γ radiation.

One of the most remarkable of the properties of the various radiations is that of producing luminescence in certain substances on which they fall, and more particularly remarkable is the scintillating property of the α rays. This property was first discovered by Sir William Crookes, and independently by Elster and Geitel, in 1903, but five years elapsed before its full significance was recognised; for it is now known that each scintillation is produced by a single α particle or atom of Helium. Crookes made a screen by dusting Sidot's blende (phosphorescent crystalline zinc sulphide) on glass. On bringing up a source of radium the screen lit up with a greenish phosphorescent light which, when examined under a magnifying glass, was found to consist of a number of scintillating points of light.

Subsequent work has shown that many other substances show this scintillating property though the scintillations are generally fainter than with zinc sulphide; the best known substances being willemite (a mineral containing zinc silicate) barium platinocyanide and diamond. Many of these materials appear to require the presence of some impurity; thus pure zinc sulphide does not show scintillations while some of the purest diamonds fail to respond to any of the radium radiations. In nearly all cases also the scintillating substances appear to lose their sensitiveness under prolonged action of the α rays, and for this reason the zinc sulphide screens of Crooke's spintharioscopes after a time need renewal. Diamond and willemite are more stable than zinc sulphide, for they retain their scintillating power longer, while barium platinocyanide, on the other hand, is very rapidly transformed under the action of α rays.

It was at first thought by Becquerel and others that the scintillations produced in zinc sulphide, for example, are the direct result of the mechanical fracture or cleavage of the crystals by the α particles, since it is well known that zinc sulphide is very sensitive to mechanical shocks. Recent evidence, however, appears to discredit this hypothesis and points to the conclusion that the scintillations are in some way the result of the enormous local ionisation produced in the zinc sulphide by the α particles; for it is well known that an α particle produces about two hundred thousand ions, before its energy is absorbed.

In 1908, Rutherford and Geiger succeeded in detecting the emission of a single α particle by an electrical method and were thus able to count the α particles from a given quantity of radium. By comparing this number with the number of scintillations produced under proper conditions on a zinc sulphide screen they were able to show that practically every α particle produces a scintillation. Thus the scintillation method can be used for quantitative measurements in radioactivity and this method has since proved of very great value in such investigations; for the electrical method of counting α particles is cumbersome and requires very special apparatus. A piece of glass or other transparent material is coated with small crystals of sinc sulphide and the observations are made in a dark room with a

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microscope of magnifying power in the neighbourhood of fifty. A good combination is a Leitz No. 0 eye-piece with a No. 4 or No. 3 objective, while it is better to have the screen very slightly illuminated so that the eye may be continuously focused on it. The source is arranged so that the scintillations appear at a rate not greater than about ninety per minute and not less than about five per minute, these rates being generally the limits for accurate counting. In some cases it is necessary to have the source and screen in a vessel at reduced pressure owing to the limited "range" of the α particles. The scintillations are timed with a stop watch. They do not appear regularly but are distributed according to chance, and to obtain an accurate estimate a large number of scintillations must be counted—in fact, the scintillation method has given an interesting experimental confirmation of the laws of probability as applied to radioactive disintegration.

Perhaps one of the most interesting experiments with scintillations is that originally used by Geiger and Marsden in the detection of the short-lived α ray products after thorium and actinium emanations. Thorium emanation is a gaseous radioactive product emitting α particles and followed by a second α ray product whose mean life is only one-fifth of a second, while actinium emanation is similarly followed by an α ray product of mean life only one three hundred and fiftieth of a second. Figure 64 shows a "drawing room" modification of the apparatus designed by Mr. F. H. Glew.

S_1 and S_2 are two zinc sulphite screens lying one above the other and separated by thin paper strips K.K. The upper screen is very thinly coated so that it is practically transparent and scintillations on the lower screen can be seen from above. M is a source of thorium emanation consisting of a very small amount of mesothorium. The emanation diffuses beween the screens in an amount regulated by the small strip P.

Consider an atom of the emanation which disintegrates between the screens emitting an α particle which produces a scintillation on either the upper or lower screen. The atom of thorium A produced from this emanation atom has an expectation of life of one-fifth of a second before in its turn it disintegrates, and gives off a second α particle which causes a scintillation on either S_1 or S_2. Thus the result is two scintillations, one following the other with about one-fifth of a second interval. These scintillations appear on about the same area of the screens and can be observed by an ordinary pocket magnifying glass or microscope. In the case of actinium emanation the scintillations are given off with an average interval of one three hundred and fiftieth of a second, so that the interval cannot be distinguished by the eye, the result being apparently two scintillations at the same time, generally very slightly separated in position.

The scintillation method has also had an important application in the study of the scattering of α particles by matter. When a parallel pencil of α particles is incident on a thin metal foil, the individual α particles suffer deflection by the atoms with which they come in contact and the beam as a consequence becomes scattered. The distribution of α particles in the scattered beam can be observed by scintillations and from this distribution considerable evidence can be drawn as to the electrical forces inside the atoms causing the scattering. Thus it has been shown that all atoms are constituted in some respects similar to small models of our solar system. They appear to have a very strong central charge consisting of a number of elementary charges equal to half the atomic weight. This central charge appears to be concentrated within a volume extremely small compared with the size of the atom and to be surrounded by electricity of the opposite sign which on our analogy may be compared with planets.

A PROPOSED BRITISH ECOLOGICAL SOCIETY.

THE British Vegetation Committee, which was founded in 1904, has up to the present consisted only of active workers in Plant Ecology, and has met with a very large measure of success. In fact, it has had to be enlarged, and includes so many "associate members" that a new Society is being formed to take its place and push forward its work. It is felt that the organisation of a Society with a regularly published and carefully edited journal might succeed also in bringing the most scattered workers—many of whom are still outside the ranks of the Committee—into touch with one another, and would keep them informed of the progress of the subject. Such a Society might also perform a similar function for the many who are keenly interested in Ecology without themselves being active workers in the field.

It is suggested that it should be called the British Ecological Society, and that the annual subscription should be one guinea, and it must be pointed out that it is intended to have a paid Secretary and Editor, and to publish a quarterly journal containing to begin with twelve thousand words in each number, which would be sent post free to members, and sold to non-members at 3s. per number.

From a circular which has been issued by the British Vegetation Committee, and signed by Dr. W. G. Smith, of the Glasgow and East of Scotland Agricultural College, and Mr. A. G. Tansley, M.A., University Lecturer in Botany Cambridge, we further learn that the Society would meet once or twice a year in different centres, for two or three days, and that the journal would include articles and notes on methods, on special points of importance, reports of proceedings of the Society, with accounts of Ecological work in progress. It would also make a feature of prompt reviews of all important recent publications, on British vegetation as well as foreign work which has a bearing on British Ecology.

The price of the journal and the rate of subscription to the Society mentioned above are to be regarded as provisional; if sufficient promises of support are forthcoming, it will be possible to fix the subscription at much less than a guinea.

It will be of the greatest assistance to the British Vegetation Committee if readers of "KNOWLEDGE" who are interested in this proposal will communicate, as soon as possible, with the Secretary of the Committee, Dr. W. G. Smith, 9, Braidburn Crescent Edinburgh, stating whether they are prepared to join the proposed Society at a subscription of one guinea per annum; if not, whether they are willing to join at a lower rate of subscription, stating the amount they would be willing to pay; and whether they have any criticisms or additional suggestions to make with regard to the scheme proposed.

THE FACE OF THE SKY FOR MARCH.

By A. C. D. CROMMELIN, B.A., D.Sc., F.R.A.S.

Date.	Sun. R.A.	Sun. Dec.	Moon. R.A.	Moon. Dec.	Mercury. R.A.	Mercury. Dec.	Venus. R.A.	Venus. Dec.	Jupiter. R.A.	Jupiter. Dec.	Saturn. R.A.	Saturn. Dec.	Neptune. R.A.	Neptune. Dec.
Greenwich Noon.	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°	h. m.	°
Mar. 2	22 51·1	S. 7·3	18 51·1	S. 29·1	23 45·0	S. 1·6	1 33·7	N.15·4	18 52·0	S.22·8	3 45·3	N.18·0	7 41·1	N.20·9
,, 7	23 9·7	5·4	22 52·0	S. 9·4	0 12·2	N. 2·6	1 48·1	15·4	18 55·5	22·7	3 46·6	18·1	7 40·7	20·9
,, 12	23 28·1	3·4	2 30·1	N.18·2	0 31·1	5·8	2 1·1	17·1	18 58·8	22·6	3 48·0	18·2	7 40·5	20·9
,, 17	23 46·4	S. 1·5	7 17·5	N.27·4	0 38·8	7·6	2 12·4	18·9	19 1·9	22·6	3 49·6	18·3	7 40·2	21·0
,, 22	0 4·7	N. 0·5	12 5·1	S. 0·4	0 34·7	7·5	2 21·5	20·2	19 4·7	22·5	3 51·3	18·4	7 40·1	21·0
,, 27	0 22·8	N. 2·5	16 40·1	S. 27·2	0 22·5	N. 5·8	2 27·8	N.21·2	19 7·3	S.22·4	3 52·2	N.18·5	7 39·9	N.21·0

TABLE 11.

Date.	Sun. P	Sun. B	Sun. L	Moon. P	Jupiter. P	Jupiter. B	Jupiter. L_1	Jupiter. L_2	Jupiter. T_1	Jupiter. T_2	Saturn. P	Saturn. B
Greenwich Noon.	°	°	°	°	°	°	°	°	h. m.	h. m.	°	°
Mar. 2	−21·9	−7·2	296·1	− 5·0	−6·4	−1·9	297·0	346·6	1 43 *e*	10 17 *e*	−2·4	−24·5
,, 7	23·1	7·3	230·2	−21·0	6·8	1·9	6·0	17·5	1 59 *m*	1 35 *m*		
,, 12	24·1	7·2	164·3	−17·2	7·1	1·8	75·1	48·4	7 47 *e*	8 35 *e*	2·5	24·7
,, 17	24·9	7·1	98·4	+ 7·3	7·4	1·8	144·3	79·4	8 3 *m*	9 48 *m*		
,, 22	25·5	6·9	32·5	+21·9	7·7	1·8	213·5	110·5	3 59 *e*	8 56 *m*	−2·5	−24·8
,, 27	−26·0	−6·7	326·6	+ 7·3	−8·0	−1·8	282·8	141·6	4 15 *m*	6 0 *e*		

TABLE 12.

P is the position angle of the North end of the body's axis measured eastward from the North Point of the disc. B, L are the helio-(planeto-)graphical latitude and longitude of the centre of the disc. In the case of Jupiter L_1 refers to the equatorial zone, L_2 to the temperate zone, T_1, T_2 are the times of passage of the two zero meridians across the centre of the disc; to find intermediate passages apply multiples of $9^h\ 50\frac{1}{2}^m$, $9^h\ 55\frac{1}{2}^m$ respectively.

The letters *m*, *e*, stand for morning, evening. The day is taken as beginning at midnight.

THE SUN continues his Northward march. It crosses the Equator $21^d\ 5^h\ 18^m\ m$, when Spring commences. Sunrise during March changes from 6–51 to 5–42; sunset from 4–43 to 5–35. Its semi-diameter diminishes from 16′ 10″ to 16′ 2″.

MERCURY is an evening star till the 27th. It is well-placed for Northern observers. Illumination four-fifths at beginning of month, zero on 27th. Semi-diameter increases from 3″ to $5\frac{1}{2}$″.

VENUS is an evening Star, having passed its greatest elongation on February 12th. Illumination diminishes from $\frac{2}{5}$ to $\frac{1}{5}$, semi-diameter increases from 15″ to 23″. The planet is very favourably placed for observation by Northern observers till the end of the month, when the crescent grows narrow. Greatest brilliancy attained $19^d\ 3^h\ e$.

THE MOON.—New $8^d\ 0^h\ 22^m\ m$; First Quarter $15^d\ 8^h\ 58^m e$; Full $22^d\ 11^h\ 56^m m$; Last Quarter $29^d\ 0^h\ 58^m e$. Apogee

Date.	Star's Name.	Magnitudes.	Disappearance. Mean Time.	Disappearance. Angle from N. to E.	Reappearance. Mean Time.	Reappearance. Angle from N. to E.
1913.			h. m.	°	h. m.	°
Mar. 12 ...	BD+18°347	6·9	6 28 *e*	74	—	—
,, 13 ...	23 Tauri	4·3	10 5 *e*	61	10 58 *e*	282
,, 13 ...	η Tauri	3·0	10 46 *e*	28	11 19 *e*	314
,, 13 ...	26 Tauri	6·6	11 8 *e*	101	—	—
,, 13 ...	27 Tauri	3·7	11 18 *e*	59	0 7* *m*	284
,, 13 ...	28 Tauri	5·2	11 26 *e*	37	0 3* *m*	306
,, 16 ...	BAC 1848	5·6	1 18 *m*	88	2 7 *m*	281
,, 16 ...	49 Aurigae	5·1	4 46 *e*	108	5 58 *e*	254
,, 16 ...	51 Aurigae	5·8	7 13 *e*	39	7 52 *e*	336
,, 17 ..	ϵ Geminorum	5·5	7 52 *e*	142	8 52 *e*	252
,, 23 ...	BAC 4261	6·9	—	—	2 45 *m*	270
,, 23 ...	Spica	1·2	8 42 *e*	77	9 23 *e*	351
,, 24 ...	BAC 4531	6·0	2 44 *m*	158	3 40 *m*	267
,, 27 ...	BAC 5465	7·3	—	—	3 17 *m*	343

TABLE 13. Occultations of stars by the Moon visible at Greenwich.

The asterisk indicates the day following that given in the Date column.

From New to Full disappearances take place at the Dark Limb, from Full to New reappearances.

Attention is called to the occultation of the Pleiades on March 13th and that of Spica on the 23rd.

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6^d $8^h m$, semi-diameter 14′ 43″; Perigee 21^d Noon, semi-diameter 16′ 41″. Maximum Librations, 1^d 7°N, 14^d 8° E., 16^d 7° S., 27^d 7°W., 28^d 7° N. The letters indicate the region of the Moon's limb brought into view by libration. E. W. are with reference to our sky, not as they would appear to an observer on the Moon.

MARS is a morning Star, but practically invisible.

JUPITER is still badly placed, having been in conjunction with the Sun on December 18th. It is a morning star. Polar semi-diameter, 16½″.

Day.	West.	East.	Day.	West.	East.
Mar. 1	34 ○	12	Mar. 17	432 ○	1
,, 2	3½ ○	4●	,, 18	41 ○	32
,, 3	3/2 ○	14	,, 19	○	4½3
,, 4	1 ○	324	,, 20	21 ○	43
,, 5	○	1/2 34	,, 21	2 ○	134
,, 6	2 ○	34 1●	,, 22	3 ○	24 1●
,, 7	1 ⊙	4 2●	,, 23	31 ⊙	4
,, 8	3 ○	124	,, 24	32 ○	14
,, 9	3½ ○	4	,, 25	1 ○	24 3●
,, 10	3/2 ○	41	,, 26	○	1243
,, 11	1/4 ○	32	,, 27	21 ○	43
,, 12	4 ○	½ 3	,, 28	42 ○	13
,, 13	421 ○	3	,, 29	43 ○	2 1●
,, 14	4 ⊙	3 2●	,, 30	43 ⊙	2
,, 15	43 ○	12	,, 31	432 ○	1
,, 16	4312 ○				

Configurations of Jupiter's satellites at 5^h *m* for an inverting telescope.

TABLE 14.

Satellite phenomena visible at Greenwich, 2^d 5^h 6^m IV. Oc. R.; 5^d 6^h 9^m II. Sh. I.; 6^d 4^h 19^m 44^s I. Ec. D.; 7^d 4^h 16^m III. Tr. I.; 4^h 58^m I. Tr. E.; 5^h 54^m II. Oc. R.; 13^d 6^h 13^m 30^s I. Ec. D.; 14^d 3^h 39^m III. Sh. I.; 4^h 38^m I. Tr. I.; 5^h 42^m I. Sh. E.; 15^d 4^h 10^m I. Oc. R.; 21^d 5^h 18^m I. Sh. I.; 6^h 0^m 46^s II. Ec. D.; 23^d 3^h 14^m II. Tr. I.; 3^h 20^m I. Tr. E.; 3^h 26^m II. Sh. E.; 29^d 4^h 29^m 21^s I. Ec. D.; 30^d 2^h 57^m I. Tr. I.; 3^h 15^m II. Sh. I.; 3^h 57^m I. Sh. E.; 5^h 14^m I. Tr. E.

All the above are in the morning hours.

The first eclipse of IV. occurs on the 18th; the first transit occurred February 4th.

SATURN is an evening Star, 6° South of the Pleiades. Polar semi-diameter 8″. The major axis of the ring is 41″, the minor axis 17″. The ring is now approaching its maximum opening and projects beyond the poles of the planet.

East elongations of Tethys (every fourth given). March 4^d $11^h{\cdot}5$ *m*, 12^d $0^h{\cdot}9$ *m*, 19^d $2^h{\cdot}2$ *e*, 27^d $3^h{\cdot}5$ *m*. Dione (every third given). March 1^d $11^h{\cdot}2$ *e*, 10^d $4^h{\cdot}3$ *m*, 18^d $9^h{\cdot}5$ *m*, 26^d $2^h{\cdot}7$ *e*.

Rhea (every second given). March 9^d $6^h{\cdot}7$ *e*, 18^d $7^h{\cdot}8$ *e*, 27^d $8^h{\cdot}8$ *e*.

For Titan and Iapetus, E. W. mean East and West elongations, I. S. Inferior and Superior Conjunction, Inferior being to the North, Superior to the South. Titan, 3^d $3^h{\cdot}1$ *e* E., 7^d $3^h{\cdot}7$ *e* I., 11^d $0^h{\cdot}1$ *e* W., 15^d $11^h{\cdot}3$ *m* S., 19^d $2^h{\cdot}9$ *e* E., 23^d $3^h{\cdot}7$ *e* I., 27^d $0^h{\cdot}2$ *e* W. Iapetus 11^d $9^h{\cdot}6$ *m* W., 31^d $7^h{\cdot}4$ *e* S.

URANUS is invisible, having been in conjunction with the Sun on January 24th.

NEPTUNE was in opposition on January 14th. Its motion may be traced on the map of small stars which was given in "KNOWLEDGE" for December, 1911, page 476.

METEOR SHOWERS (from Mr. Denning's List):—

Date.	Radiant. R.A.	Radiant. Dec.	Remarks.
Mar. 1—14	166°	+ 4°N	Slow, bright.
,, 14 ...	250	+ 54 N	Swift.
,, 18 ...	316	+ 76 N	Slow, bright.
,, 24 ..	161	+ 58 N	Swift.
,, 27 ...	229	+ 32 N	Swift, small.
Mar. to May	263	+ 62 N	Rather, swift.

DOUBLE STARS AND CLUSTERS.—The tables of these given last year are again available, and readers are referred to the corresponding month of last year.

VARIABLE STARS.—Tables of these will be given each month; the range of R.A. will be made four hours, of which two hours will overlap with the following one. Thus the present list includes R.A. 8^h to 12^h, next month 10^h, to 14^h, and so on. In the case of Algol variables, the time of one minimum is given where possible, and the period. Algol, owing to its brightness, will be given for wider limits.

ALGOL STARS.

Star.	Right Ascension. h. m.	Declination.	Magnitudes.	Period. d. h. m.	Date of Minimum. d. h. m.
Algol	3 2	+40°·6	2·3 to 3·4	2 20 49	Mar. 3 11 58 *m*
X Carinae	8 29	—58 ·9	7·8 to 8·6	0 12 59·6	Feb. 2 0 36 *e*
S Cancri	8 39	+19 ·4	8·2 to 9·8	9 11 38	Mar. 10 11 59 *m*
S Velorum	9 30	—44 ·8	7·8 to 9·3	5 22 24·4	Feb. 28 8 27 *e*
Y Leonis	9 32	+26 ·7	9·0 to 10·6	1 16 28	Mar. 1 4 54 *e*
W Urs. Maj.	9 38	+56 ·4	7·9 to 8·7	0 4 0·2	
ST Urs. Maj	11 23	+45 ·7	6·7 to 7·2	8 19	

NON-ALGOL STARS.

Star.	Right Ascension. h. m.	Declination.	Magnitudes.	Period. d.	Date of Maximum.
V Cancri	8 17	+17°·5	7·1 to 12·8	272	Feb. 7. Nov. 6.
T Lyncis	8 17	+33 ·8	8·5 to 11·2	91	Mar. 23.
Z Cancri	8 18	+15 ·3	8·5 to 9·2	74	Mar. 29.
S Hydrae	8 49	+ 3 ·4	7·5 to 12·2	256	Apr. 1.
Y Draconis	9 32	+78 ·3	8·2 to 11	336	Feb. 23.
R Leonis	9 43	+11 ·8	5·0 to 10·2	313	Feb. 9.
Z Leonis	9 47	+27 ·3	7·9 to 9·6	59	Apr. 6.

TABLE 15.

NOTES.

ASTRONOMY.

By A. C. D. Crommelin, B.A., D.Sc., F.R.A.S.

PHOTOGRAPHY OF THE MILKY WAY. — Mr. d'Esterre's results should be an encouragement to the possessors of small photographic apparatus. He has selected a limited region of the Milky Way, near the great Perseus cluster, and keeps a constant photographic patrol upon it with a six and a half-inch Voigtlander camera and some smaller instruments, also occasional visual observation with a fifteen-inch reflector. His zeal has been rewarded by the discovery of a faint Nova (87, 1911), which is interesting as being one component of a double star; also several variables. Observations of these are contained in *Astronomische Nachrichten*, No. 4623, with diagrams of the fields.

It is likely that observers who selected other regions, and followed them with the same pertinacity, would reap similar harvests.

ATTRACTION OF SUNSPOTS FOR PROMINENCES.—*The Astrophysical Journal* for November contains an interesting article by Mr. F. Slocum on the large sunspot of October, 1910, illustrated by several spectroheliograms in calcium light. The prominences round the spot appear to have been strongly attracted by it, and were seen in successive photographs to approach it with accelerated motion. Professor Hale and Mr. Evershed had previously noticed that the gases round sunspots were moving inwards, but their observations indicated that the inward motion was retarded, not accelerated. It was formerly debated whether sunspots were formed by inrushes or outrushes of gas. The new observations would seem to favour the former, but it must be remembered that an inrush at one level may be accompanied by an outrush at another. I remember being in a boat on the Thames immediately over the outrush of water from a lock-sluice; contrary to expectation a counter current carried our boat violently against the lock gate. Any violent current generally produces a backwash. In fact, Mr. Slocum finds evidence of such outward motion on a few of the plates, but it is less marked and less persistent than the inward motion.

NOVA GEMINORUM (2).—The same number of *The Astrophysical Journal* contains an interesting article by Walter S. Adams and Arnold Kohlschutter on the spectrum of this Nova. Photographic spectra on dates ranging from 1912, March 22nd to August 19th, are reproduced, and the spectrum of a Wolf-Rayet star is given for comparison with the last. It has some points of resemblance, but great difference in relative intensities of lines. The authors sum up the changes in the Nova's spectrum thus:—

(1) The continuous spectrum got steadily weaker.

(2) An increase in the number and intensity of the nebular lines. The chief nebular line, λ 5007, was first seen on April 6th, and afterwards became very strong. The second line, λ 4959, was first seen on April 22nd, and rapidly grew stronger. The nebular lines at λ 4364, 4687 also got strong in the later photographs.

Using the narrowest and best-defined lines to find the radial velocity of the Nova, they deduce a recession from the Sun of ten kilometres per second, close to the mean of the values nine kilometres, twelve kilometres, and seven kilometres found by Curtiss, Plaskett, and Küstner. They do not consider that variation in the velocity is established, though it is not impossible.

They find no evidence of the presence of radium in the Nova, which other observers had suspected.

SIGNS OF REVIVING SOLAR ACTIVITY.—It is well-known that the last sunspot cycle was abnormal: the maximum was delayed three or four years after the time deduced from the eleven year period. There was also a double maximum. It is therefore difficult to predict for the coming cycle, but we may anticipate a revival in the near future. One sign of the beginning of a new cycle is the outbreak of spots in higher solar latitudes. Mr. Maunder noted at the December Meeting of the British Astronomical Association that a spot had appeared in relatively high latitude, which might be the harbinger of the new cycle. Professor Schuster expects a distinct awakening of activity about next May. This is based on his four-year cycle of activity, whose reality is questioned by some students of the Sun. In any case we are probably near the beginning of the new cycle, and a careful watch should be kept on the Sun.

SOLAR ECLIPSES.—Our sympathies must be extended to the numerous astronomers who visited Brazil last October for the solar eclipse. Heavy rain prevented any results. An interesting account of the English expedition is given by Mr. Eddington in the January number of *The Observatory*. The eclipse was an unusually dark one, and the descent of the darkness and return of the light were both sudden.

There will be an important total eclipse in August, 1914, the central line crossing Norway, Sweden and Russia. The official British expedition proposes to go to the Crimea, but there are so many accessible points on the line that the parties are likely to be widely distributed. The British Astronomical Association will probably organise an expedition to Norway. If it prove as great a social success as that of 1896, and is favoured by kindlier skies, no one is likely to regret taking part in it.

BOTANY.

By Professor F. Cavers, D.Sc., F.L.S.

BIOLOGY OF DESERT PLANTS.—Dr. D. T. Macdougal, Director of the botanical research department in the Carnegie Institution at Washington, has recently published (*Ann. Bot.*, Vol. XXVI) a further memoir on the "water-balance" of desert plants. The water-conducting tissues of flowering plants are closely connected with distensible tracts of tissue (*e.g.*, cortex and pith) which have an appreciable capacity for the retention of water in plants of even the most sparing habit and structure. As the ascending water-current passes from the root-hairs to the leaves, some of it may go into such masses of tissue forming reservoirs in the roots, stems, or leaves; this accumulated supply may be drawn out to the transpiring cells when the pressure of the solution in the cell-sap is overcome. All plants with massive stems may thus carry a large balance of water, and this stored solution may play an important part in the plant's life. The relatively largest balances are borne by some of the species characteristic of the arid regions of the south-western and southern parts of North America, some parts of South America, and the southern parts of Africa; while North Africa, Asia, Australia, and arid regions in high latitudes everywhere have but few plants with a large water-balance. The present paper deals with observations made in the Tucson region of Arizona, which has a winter rainy season and a wet midsummer, with a hot dry fore-summer and arid after-summer. The total average annual rainfall is about twelve inches only; the extremest arid effects are seen in June and July, when the humidity falls as low as six per cent. with midday temperatures of 110° F.

In desert regions the vegetation includes a number of rapidly-maturing forms, which carry out their entire life cycle during regular or irregular periods of rainfall, and which are physiologically mesophytes—plants without any marked adaptations for checking transpiration; other forms

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requiring much moisture occur along streams. Apart from these, the specialised forms which are more or less active during the dry seasons comprise two types—the sclerophyllous and the succulent.

The sclerophyllous type iucludes a large number of woody and spiny herbs and shrubs with reduced branches, restricted foliage, and hardened surfaces. These xerophytes have a very small water-balance, and the cell-sap often shows great concentration—sometimes over one hundred atmospheres of osmotic pressure. The specialisations shown by sclerophyllous forms are of a direct physiological character, and entail the least change in habit and structure.

The succulents show most of the external features of the spinose xerophytes, which may be carried to extreme limits, as in the Cacti where the entire shoot may be reduced to a short cylindrical or globose form, while there is great increase in the extent of the pith and cortex enabling the plant to carry a large water-balance. The cell-sap of succulents usually shows a comparatively low osmotic pressure—rarely more than about ten atmospheres, though it may increase greatly with desiccation.

The author describes experiments in which various plants were subjected to desiccation, and the effects of depletion of the water-balance noted. The large tree Cactus (*Carnegiea gigantea*) may survive for a year or even more without receiving additional water from the soil, but flowers are not formed in the arid fore-summer unless the plant has received its supply of water during the previous winter rainy season, nor would apical growth ensue in midsummer unless the summer rains were available. In *Echinocactus* both root development and apical growth of the stem, with some capacity for flower formation as well, were shown after one or even two years of depletion of the water-balance; individuals exposed to the full intensity of the Arizona sunlight might not survive for more than a year, though even the slightest amount of shade would greatly enhance the value of the enormous water-balance; plants in an ordinary room were in good condition after three years of deprivation of water. The flattened Opuntias may exist for two or three years without a water-supply, and may carry out seed-formation during this period; new joints may be formed, but usually at the expense of the older ones, which are destroyed during the process. In most of the plants experimented with, no notable changes in structure were shown as the result of depletion of the water-balance, except that the new organs formed were usually of minimum size. The stems of *Dioscorea*, however, showed changes tending to the sclerophyllous habit.

Five possible causes are suggested as influencing the rate of water-loss by transpiration in a succulent exposed to desiccation. (1) The increased concentration of the sap, which in the experiments was such as to increase osmotic pressures from four or five to ten or twelve atmospheres, might retard evaporation from the cell-membranes. (2) A diminution of the degree of succulence, or proportion of water per unit area of surface present, might lessen transpiration. (3) Desiccation may result in alterations in the character of the outer membranes or of any of the transpiring cell-walls of the plant. (4) Desiccation may stimulate the formation of new tissues or the alteration of existing cells in such a manner as to close openings through which water-vapour might pass. (5) The positions of the surfaces might be shifted in such manner as to vary the exposure and lessen transpiration.

With regard to (1), however, Livingston has shown that concentration of the sap, even if carried to a point where an osmotic pressure of one hundred atmospheres was attained, would not result in a retardation of more than ten per cent. in the rate of evaporation from a free water-surface; hence this factor is negligible in the present case, as the increases found were not more than five or six atmospheres.

RESISTANCE OF PLANTS TO FREEZING.—In the *New Phytologist*, Vol. VIII (1909), under the title "Vegetation and Frost," Dr. F. F. Blackman gave an interesting summary of this subject, drawn from the researches of Müller, Molisch, Mez, Gorke, and Lidforss. Müller and Molisch held that the fatal effect of freezing upon plant-cells is due to the withdrawal of water from the protoplasm; but the work of Mez went against this view. Gorke investigated the changes in composition produced by freezing either entire plants or their pressed-out sap, and showed that when water was withdrawn from the cell by freezing, the salts present became more concentrated and eventually caused the precipitation of the soluble proteins of the cell. Lidforss found that "wintergreen" plants—delicate herbaceous plants which still bear green leaves in mid-winter, though showing no obvious structural adaptation for protection against cold—contain quantities of sugar in winter, this being replaced in summer (or in winter if the plants are brought into a warm room) by starch; and his observations strongly support the view that the presence of sugar retards the "salting-out" or precipitation of the proteins, which Gorke had described.

The chemical means of protection of plants against freezing have recently been investigated by Maximow (*Ber. deutsch. bot. Ges.*, 1912). He finds that the introduction of neutral organic substances, such as carbohydrates, alcohols, and acetone, into the cells of plants increases their power of resisting cold, in the case of tropical plants as well as those of temperate climates. The protective action of such substances does not stand in direct relation to the osmotic pressure and the lowering of the freezing-point—as the concentration of the substance rises, the resistance to cold increases at a more rapid rate than the lowering of the freezing temperature. Different substances differ in their effect, and of the substances tried the sugars have the greatest effect; then come glycerine, the alcohols and acetone. On the withdrawal from the cells of the protective substance which has been artificially introduced into them, the power of cold-resistance returns to its original condition; and when "wintergreen" and other plants are placed for some time in water, their cold-resisting capacity is diminished.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (OXON), F.I.C.

THE MANUFACTURE OF SUGAR FROM SAWDUST.—In a recent issue of the *Journ. Roy. Soc. Arts* (1912, LXI, 69) there is an interesting outline by Mr. A. Zimmermann, of the manufacture and utilisation of the sugar produced by hydrolysing sawdust with an acid. The methods employed in obtaining alcohol from woody fibre have already been described in these columns and the Classen process used in the production of the new commercial product "sacchulose" is based upon similar principles. The sawdust is treated with a solution of sulphurous acid in a closed vessel under a pressure of ninety to one hundred pounds per square inch, with the result that a product containing about twenty-five per cent. of sugars and a porous friable residue of modified wood fibre is obtained.

Owing to the changes in the physical and chemical structure of the material the crude product will readily oxidise on exposure to the air, and to obviate this the "sacchulose" is mixed immediately after its formation with a certain proportion of molasses or fatty matter, with the object of preventing the air from coming into contact with the sugars.

Experiments upon the use of the mixture as a feeding stuff for animals have given very good results. The trials were made upon working horses and extended over a period of six months, four lbs. of the oats in their former daily rations being replaced by four lbs. of the prepared "sacchulose." At first the animals lost in weight, but after they had become accustomed to the change, increases in weight of thirty to eighty lbs. were recorded.

Eighty per cent. of the sugars are fermentable and the original idea of the manufacturers was to produce a cheap commercial spirit which might possibly be used as a fuel for motors. The spirit obtained by fermentation and distillation of the soluble sugars is of excellent quality, and acetic acid,

methyl alcohol and furfural could be obtained as by-products from the residue. A yield of thirty to thirty-five gallons of proof spirit would be obtainable from each ton of sawdust, and on this basis it is calculated that in a factory where two hundred tons a week were treated, the yearly output of spirit would be from three hundred thousand to four hundred thousand gallons. Unfortunately for the development of this side of the scheme, the restrictions of the Spirit Act of 1880 bar the way, and fresh legislation is required before anything can be done in this direction.

FABRICS OPAQUE TO X-RAYS.—It has long been known that silk can be loaded with various metallic salts, and advantage is taken of the fact in commerce to sell silk which is sometimes weighted with as much as one hundred and fifty per cent. of a tin salt. A more legitimate use of this absorptive power of silk is described in the *Comptes Rendus* (1912, CLV, 706) by M. L. Droit, who has found that by using certain lead salts for the weighting, a silk fabric may be rendered opaque to the passage of X-Rays. For example, a material thus prepared by treatment of the silk with lead phosphotannate and other salts contained sixty-eight per cent. of mineral matter, including thirty-four per cent. of lead oxide, twenty-four per cent. of tin oxide, eight per cent. of phosphoric anhydride, and two per cent. of lime and alkalies. Slight discharges of X-Rays were practically arrested by two layers of this fabric, while six layers were found a sufficient protection to the skin against the action of an ordinary discharge of medium strength. This fabric had the same protective effect as a sheet of copper 0·044 millimetres in thickness, and had the great advantage of flexibility, even when used in a thickness of several layers.

THE ODOUR OF CLAYS.—An investigation of the cause of the well-known characteristic odour of certain clays has been made by Dr. P. Rohland (*Zeit. physiol. Chem.*, 1912, LXXXI, 200). The peculiar odour which may be imparted to other substances either of a colloidal or crystalloidal character, is rendered more perceptible by moistening the clay with water or alkali solution, especially in the case of kaolin clay. It is suggested that in the formation of such clays during the weathering of granitic rocks, bacteria or other micro-organisms may have had a share in the disintegration and that the odour may be due to the presence of their dead cells. In support of this view it is pointed out, that organic matter is frequently present in kaolin clay, and plays a part in rendering it plastic. If the clay has been purified by sedimentation in water so that the organic colloidal substances have been removed, it ceases to be plastic. Kaolins rich in such organic matter are not only very plastic, but also possess the property of taking up other colloids to form loose absorption compounds. When kaolin clay is digested with a mixture of water and an aromatic hydrocarbon, such as benzene, it becomes quite impervious to the hydrocarbon, though it will still allow the water to pass.

COMPOSITION OF THORIANITE.—An examination of various specimens of the mineral thorianite has been made by Mr. M. Kobayashi (*Science Reports*, Tôhoku University, Japan, 1912, I, 201), who concludes that there are two varieties, one of which contains about seventy-eight per cent of thorium oxide, and about fifteen per cent. of uranium oxide, while the other contains about sixty per cent. of thorium oxide and thirty-three per cent. of uranium oxide. In the first of these varieties the rates of ThO_2 to UO_3 would thus be as 6 : 1, while in the second the ratio would be as 2 : 1. The remarkable discrepancies in analyses, previously published, of the composition of this mineral are readily explained on the assumption that the materials examined consisted of mixtures in varying proportions of the two varieties.

Some years ago a specimen of thorianite from Ceylon was described by Messrs. Dunstan and Jones (*Proc. Roy. Soc.*, 1906, LXXVII A, 546). This was very rich in uranium, and the proportion between the two oxides was taken to indicate that the uranium and thorium oxides were present in thorianite as isomorphous mixtures and were not in chemical combination. Mr. Kobayashi is opposed to this view on the grounds that the molecular ratios mentioned above could scarcely be accidental, and that while ignited thorium oxide is nearly insoluble in nitric acid, thorianite is fairly soluble even after ignition.

GEOLOGY.

By G. W. TYRRELL, A.R.C.Sc., F.G.S.

THE SUSSEX SKULL.—A most important discovery of human fossil remains has been made by Mr. Charles Dawson in a gravel-pit near Piltdown Common, Fletching, Sussex, and described at a recent meeting of the Geological Society. The section, about four feet thick, consists mainly of water-worn fragments of Wealden ironstone and sandstone, with occasional chert pebbles, and a considerable proportion of water-worn flints. In addition to a portion of a human skull which was found by workmen, Mr. Dawson obtained half a human mandible, broken pieces of the molar of a Pliocene type of elephant, a rolled cusp of a molar of *Mastodon*, and teeth of *Hippopotamus*, *Castor*, and *Equus*, with a fragment of an antler of *Cervus elaphus*. All these fossils, including the human, were well mineralised with oxide of iron. Many of the iron-stained flints resemble the "eoliths" from near Ightham, and with them were obtained a few Palaeolithic implements of Chellean type.

The Piltdown gravel is eighty feet above the river Ouse, and less than a mile to the north of the existing stream. The authors believe that the gravel is of the same age as the contained Chellean implements. The various teeth are believed to have been derived from older gravels; but the human skull and mandible, which do not show signs of water-transportation, are assigned to the period of the deposition of the gravel. The remoteness of this period is indicated by the fact that the Ouse has since deepened its valley by eighty feet.

The human remains were described by Dr. A. S. Woodward, who suggests that they belonged to a female individual, and represent a hitherto unknown genus and species. In an appendix, Professor Elliot Smith remarks that although the brain shows a general similarity to the cranial casts of Palaeolithic man, especially those of Gibraltar and La Quina, it is smaller and more primitive in form than any of these. A most noteworthy feature is a pronounced gorilla-like drooping of the temporal region, indicating feeble development of that part of the brain which is known to be related to the power of speech. Dr. Woodward concluded that the jaw was simian in type, although found in association with a human type of skull, and in this he was supported by Professor Elliot Smith and Sir E. Ray Lankester. In the discussion Professor Keith thought that the simian character of the jaw and the primitive characters of the skull were incompatible with Chellean age. In his opinion the skull was of the same age as the mammalian remains which were admittedly Pliocene. Hence he believed that Tertiary man had been discovered in Sussex. Mr. Clement Reid was of the opinion that the Piltdown deposit, and the plateau on which it rests, belong to a base-level plain which originated about the period of the Brighton raised beach. The deposit was not Pre-Glacial or even early Pleistocene, but occurred at the very base of the great implement-bearing succession of Palaeolithic deposits in the south-east of England, and belonged to an epoch long after the first cold period had passed away.

THE MOINE GNEISS.—The new geological Survey Memoir bearing the cumbrous title, "The Geology of Ben Wyvis, Carn Chuinneag, Inchbae, and the Surrounding Country," is a most interesting production, and students of the petrology of the metamorphic rocks will find in it an excellent discussion, by Dr. J. S. Flett, of the Moine and other gneisses and schists in this area. The Memoir describes an area of four hundred and thirty-two square miles, almost all of which lies in Ross-shire and extends westward from the Cromarty and Dornoch Firths. A few small inliers of Lewisian gneiss occur in the south-west, but the major part

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of the district is occupied by the Moine gneisses, which are paragneisses representing a great sedimentary series originally composed of sandstones, pebbly grits, and sandy shales. The Moine is divided into four groups, of which the one supposed to be the highest in stratigraphical sequence is pelitic or semi-pelitic in composition, and is invaded by a great mass of foliated granite (augen-gneiss), with subordinate basic and alkaline varieties. All the latter were intruded into the Moine sediments prior to the movements which transformed the rocks into gneisses. This is shown by the fact that the Carn Chuinneag granite has still preserved around it an aureole of contact-metamorphism which has resulted in the production of hard, fine-grained hornfels from the original sandy shales of the Moine. The induration of the hornfels has been such that, in many places, they have completely resisted the gneiss-making movements, and are in substantially the same condition as when first formed. Although completely recrystallized these hornfels have never been deformed or sheared, and have preserved a fine sedimentary lamination. Even sun-cracks and ripple-marks have been observed on the surfaces of the bedding planes. They, therefore, prove up to the hilt the original sedimentary character of the great series of Moine gneisses which occupy so much of the North of Scotland.

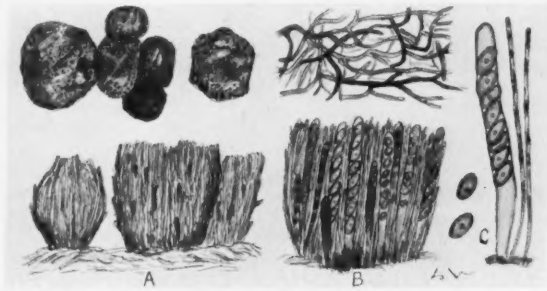

FIGURE 65. *Peziza domestica.*

MICROSCOPY.

By F.R.M.S.

A "DOMESTIC" FUNGUS.—Owing to the very wet autumn a damp spot appeared on the ceiling of a bedroom, and in a short time a small fungus developed on it. It is a species not infrequent under similar circumstances, though probably seldom identified. It begins as a cottony web-like mycelium, very delicate and invisible on the white of the ceiling, the threads composing it being without colour. On this arise minute, almost spherical, bodies, the microscope showing them to consist of fine filaments arranged side by side. As growth proceeds, these spread at the top, forming somewhat cup shaped objects, but commonly much distorted by pressure as they usually occur close together in patches. Inside they are packed with ***paraphyses***, long hair-like objects, and ***asci*** (plural of ascus) narrow sacs, each containing at maturity eight oval thin-walled ***sporidia***, arranged in one row; when ripe they measure from sixteen to eighteen μ long, by about eight μ wide, and are then ejected by means of any change of temperature or moisture. The little fungi are usually pale salmon pink, but sometimes are white, though apparently differing in no other way. This species is named ***Peziza domestica***, as it is most commonly found on damp ceilings and the plaster of walls in houses, but it occasionally arises also on burnt ground. There are some hundreds of species of the genus *Peziza*, which are in most cases elegant little cups often very minute, and grow on various objects out of doors, such as twigs, leaves, and other refuse, particularly of a vegetable character. This example is not a very typical one, as the body of it is scarcely cup-shaped, but rather sub-cylindrical with a conical base, and shows no hollow. It is small, measuring only about ·5 millimetres in diameter and frequently much less. The Pezizas are members of the Discomycetes, a very large group of the Ascomycetes, which are so named because, as in this case, the spores are formed in an *ascus*. The spores are called *sporidia* as a distinction from those arising without this organ. In Figure 65, A shows a young and mature specimen seated on the mycelium; above is sketched a surface view showing the irregular form caused by crowding. At B is a sectional view of the fungus on a larger scale, showing the asci with sporidia in various stages of growth, among the numerous paraphyses; above is some of the web-like mycelium; and at C an ascus with sporidia, two paraphyses and two free sporidia, all more highly magnified.

JAS. BURTON.

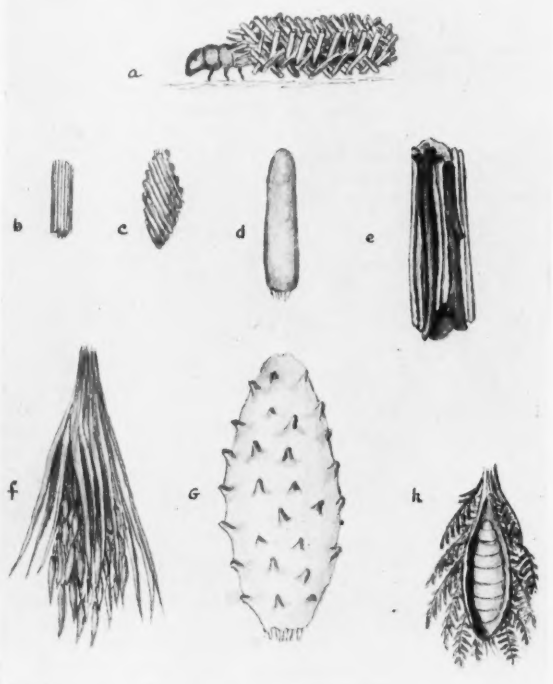

FIGURE 66. Natal Psychidae (natural size).

PSYCHIDAE.—The caterpillars of the Psychidae are amongst the most curious and wonderful to be found in the insect world, since they make and live in houses of marvellous construction which they carry about with them wherever they go. These houses differ in shape and material in different species, and though our British examples are small and inconspicuous, some of those found in South Africa and India reach a length of over three inches. Our illustration gives a selection of typical forms from Natal, drawn natural size. Of these, Figure 66A shows a caterpillar with its head and first three segments protruding from its house, the rest of the body remaining inside. In this manner it walks about and feeds, always dragging its house with it, which in this instance is formed externally of small sticks cut into short lengths symmetrically arranged and fastened together with silken threads. The inside is lined with a smooth blanket of silk, quite closed at one end, but having a door at the other end constructed of a number of stiff pieces of dried grass fastened round the edge of the blanket and attached to it in such a manner that when the occupant retires within, it can close them down and cause them to interlace so effectually that not even the smallest of insect enemies could gain admittance. When night approaches the caterpillar suspends its house from the branch of a tree by a silken cord, and then, retreating inside, closes the door and snugly reposes in its blanket

until the morning. Some which I kept alive in a box, found at first some difficulty in thus suspending themselves from the glass cover, but this was at length overcome by making a lattice-work path of silk across the underside of the glass along which they were able to walk and from which they hung their houses every evening. A number of eggs laid by the moth of one species on the flowers of one of the Compositae hatched out as the flowers were maturing, and the larvae, one thirtieth of an inch in length, immediately began to cut up the feathery pappus and constructed the most perfect little houses, which they somehow managed to enlarge as required by their growth, without alteration of the original design. In Figure 66B, the house is made of pieces of the stems of fine grass arranged in parallel lines. Figure 66C is apparently made of some kind of fibre worked together obliquely and partly covered with silk. Figure 66D is presumably made of fine fibres but is so completely covered with silk as to prevent them from being seen. Figure 66E is formed of two kinds of sticks fastened together lengthwise. Figure 66F is chiefly constructed of the dried spikelets of grass overhung with a roofing of grass leaves. Figure 66G is obviously made of sticks, the ends of some of which are seen projecting through a thick covering of silk, and Figure 66H, consisting chiefly of the small dried leaves of a Mimosa, has been cut open, showing the chrysalis inside.

The natives of Southern India, where Psychidae similar to Figure 66A are not uncommon, regard these creatures as the embodiment of the souls of men who having during their human lives been addicted to the stealing of firewood, are passing their next period of existence attached to a bundle of sticks. The Kaffirs of Natal, however, have given them the common name of Mahambanendelwhana, which, being translated, means "he that goes with his little house." Friends who sometimes complain of the long names given to insects by entomologists, will possibly think that this is no improvement.

R. T. L.

ON THE RELATION OF APERTURE TO POWER IN THE MICROSCOPE OBJECTIVE.—That opticians are human they would themselves admit, and to supply what the public demands is the essence of business with them as with everyone else. Moreover, competition is keen, and hence each tries to give his customers a better bargain than can elsewhere be obtained.

Now, by a "better bargain," the microscopical customer only too often understands objectives of higher numerical aperture, since stands, eyepieces, and condensers of similar quality are now much the same price everywhere. But A puts into his a two-third inch of N.A. ·30 and a one-sixth inch of ·88, B gives N.A. ·28 and ·74 respectively, whilst C gives ·25 and ·65 for these same lenses. The one-twelfth oil immersion is almost invariable everywhere nowadays, being of about N.A. 1·30, and costing five pounds.

In the above case A would often get the order, the tyro arguing that increased N.A. meant more resolution, and therefore better results. It is altogether forgotten that behind everything is the human eye, and that this admits of improvement within but narrow limits. Let us see what those limits are.

The standard distance for ordinary eyesight is ten inches. Most people can with but little practice, by the aid of a rule divided into tenths, prick off divisions as small as the one-hundredth part of an inch. We may take this as fairly easy.

Now let us go a step further and ask how closely can we read a millimetre scale? Remember a millimetre is practically one twenty-fifth of an inch. Can we without a vernier, or lens or any other extraneous aid, read it closer than to one-fifth of a division, *i.e.*, one hundred and twenty-fifth of an inch? Very few would say that this was possible with ease, and, above all, certainty. Rule, *e.g.*, a few lines of different lengths. Obtain a glass scale with millimetre divisions on the lower surface (so as to avoid parallax) then measure the lines and put the measurements down on paper. Ask others to do the same, and you will find that the fifth of a millimetre is about the average of good ordinary eyesight, and that even if one has large powers of accommodation and can, for instance, read ordinary print at, say, five inches distance, yet the millimetre scale will still defeat us if we attempt to read it closer than fifths.

Let us go elsewhere for confirmation. Vega forms the brightest of a small triangle of stars distant from each other less than two degrees. The one N.E. of Vega is ϵ Lyrae, a noted double double. Most people cannot see it double at all. Many astronomers can separate them without artificial aid. Smyth says: "The naked eye sees an irregular-looking star near Vega, which separates into two pretty wide ones under the slightest optical aid. "So," adds Webb, "I see it, and probably most observers," but notes that Herschel, Bessel and "many others have divided it with the naked eye." The distance is three minutes twenty-seven seconds. This angle corresponds almost exactly to one hundredth of an inch at a distance of ten inches.

Now let us return to the microscope. In Mr. Conrad Beck's Cantor Lectures on "The Theory of the Microscope" page 40, we read, "It is generally considered that for every one hundred magnifying power the numerical aperture should not be less than about ·2 N.A.

Now, a numerical aperture of ·2 should resolve nineteen thousand three hundred lines to the inch. With a power of one hundred we must be able to separate lines $\frac{1}{19200} = \frac{1}{193}$ of an inch. This agrees well with Professor Abbe's calculations, which are based on the assumption that the human eye can distinguish intervals, having an angle of two minutes or $\frac{1}{172}$ at ten inches. Mr. E. M. Nelson puts the ratio as a magnification of one hundred to ·26 N.A. Now, ·26 N.A. will resolve twenty-five thousand lines per inch. In this case, therefore, we get the limit of resolution of the eye itself given as two hundred and fifty lines per inch. Professor Abbe's researches date from 1874–5; Mr. Nelson's opinion dates from 1883; whilst Mr. Conrad Beck's lectures were given in December, 1907.

We may approach the solution of the question by asking at the very commencement what eyepiece magnification and what tube length must we predicate? As regards the latter we have no choice, the six-inch tube (one hundred and sixty millimetres) being now almost universal. Eyepieces, too, are now almost universally the same and give, with the one hundred and sixty millimetres tube, powers of 3, 4, 5·5, 7, and 9. Professor Abbe gives the upper limit of eyepieces as ten with N.A.·10 and only four with N.A.·90. His researches, as I have just said, date from 1874 when the substage illumination, at least on the Continent, was of the most primitive description. At the present day, whilst the experienced worker confines himself as far as possible to low and medium eyepieces, he does not hesitate to use the higher if required to reveal structure. Much, however, depends on his objectives.

Passing over the lower power lenses, which are used only as finders, we come to those useful medium powers ranging from the one-inch to the half-inch or four-tenths of an inch, which consist usually of two doublets.

These admit abundance of light and often possess a working distance equal to three-quarters of their focal length. They can scarcely be said to be used for highly critical work and will bear an eyepiece magnification of at any rate more than ten. Professor Abbe gives such moderate powers an eyepiece amplification of 5·5 to 9 and since his day the excellence of objectives has advanced all along the line thanks to the Abbe-Schott glass and other causes, so that nowadays every objective of four-tenths of an inch or lower will bear an eyepiece magnifying ten on the one hundred and sixty millimetres tube. Even then we must be careful as to the illumination or we shall only get a foggy glare.

Dry objectives of high power ranging from, say, one-quarter of an inch to one-tenth of an inch now almost invariably consist of a hemispherical front with two correcting systems of lenses behind. It is not easy to make such a combination much lower than ·60 N.A. and they range as a general rule from ·60 to ·90 N.A. It is with these that the greatest improvement of all has taken place. The new optical glass, and especially the use of fluorite in one of the back combinations, have led to such an advance in the colour corrections of these series that nowadays one can often scarcely see the

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difference between them and the apochromatic, so inconspicuous is the secondary spectrum. For photographic work, with the monochromatic screen, they are equally as useful as the much higher-priced lenses. Their spherical correction is excellent, at any rate up to nearly ·90 N.A. We, however, begin to note a falling-off in the quality of the image under the higher eyepieces, though nearly all stand an eyepiece of ×10 with little or no deterioration. It may be said that photographs show that such powers will give good definition up to nearly fifteen times their initial power. But in photography there are no *muscae* to disturb the sight, and the effect is, above all, cumulative. Even for photography this limit is never exceeded, except for well-marked objects like such diatoms as are well within the resolving power of the objective.

We may, therefore, take it that one hundred and twenty-five lines to the inch is about the average power of resolution for the ordinary eyesight, and that an eyepiece magnification of ten can be used with any objective of the present day consistently with perfect definition and sufficiency of light.

We must now endeavour to find out the initial power of the objective suitable for each numerical aperture. This is fairly obvious.

An objective of ·13 N.A. will resolve twelve thousand five hundred lines to the inch according to the well-known tables of the Royal Microscopical Society, the accuracy of which have never been impugned. To accomplish this the objective must have an initial power of ten which, multipled by ten (the power of the eyepiece), and then by one hundred and twenty-five (the limit of resolution of ordinary eyesight), gives us the twelve thousand five hundred required.

Now an objective with an initial power of ten must be of sixteen millimetres focus, *i.e.*, two-thirds of an inch. Thus, a sixteen-millimetre objective should possess an aperture of ·13. The lowest usually made at the present day is ·20 N.A., so that it has a large surplus of aperture, and would resolve nineteen thousand two hundred and eighty-two lines to the inch with an eyepiece magnifying 15·4 times. As a matter of fact, it is easier to make a sixteen-millimetre objective of the higher N.A. than as low as ·13 N.A., which latter could only be done easily by using a single achromatic triplet which would not bear an eyepiece of more than × 7.

We may now construct a table of magnifications of the corresponding N.A., and of the focus of the objective required to obtain that magnification with an eyepiece amplification of **×10.**

Magnification.	N.A.	Focal length of Objective.
100	·13	16·0 mm.
200	·26	8·0 „
300	·39	5·33 „
400	·52	4·0 „
500	·65	3·2 „
600	·78	2·67 „
700	·91	2·3 „

The point to be observed is that the above are the minimum figures really required. As we have said, it is not easy to make objectives of as low a numerical aperture as the first five, owing to optical difficulties. Nor would an addition of reasonable amount be objectionable, so long as proper working distance be kept in view. It is, however, useless to give us a four-millimetre (one-sixth) objective of N.A. ·88, as its aperture could not be fully utilized except by employing such high power eyepieces or lengthening the tube as would utterly break down the critical character of the image. Anything above ·52 N.A. for such an objective is of little or no value, and if working distance is sacrificed to obtain a higher aperture it is worse than useless. As a matter of fact ·65 N.A. is the lowest aperture in which such a lens is made. Fortunately, opticians are beginning to see this, and we have now objectives of this focus beautifully corrected with a working distance of one millimetre, thus allowing them to be used with Thoma-Zeiss Haemocytometer, or with thick covers.

It will be said that greater aperture means more light, but in these days of efficient condensers this is no desideratum. As a general rule, the light nowadays is oftener too much than too little.

Besides, we sacrifice depth of focus, which is too often confounded with working distance, but which really varies inversely with the N.A. Thus, in two six-millimetre objectives of ·62 and ·92 N.A. respectively, the former would possess a depth of focus of 1·6, the latter that of 1·1 only, or one and a half times the latter—an important point, especially in micro-photography.

It may be added that the one-twelfth homogeneous immersion usually sold cannot be improved upon either in aperture or power, as will be seen if the reader will carry on the figures in the above. It possesses a good proportion of aperture to power and reasonable working distance, considering the aperture.

It will be asked what size would the disc of confusion be with such low apertures? The usual formula being employed, we have $\frac{100}{95000 \times \cdot 13} = \frac{1}{123 \cdot 5}$ inch which is at any rate a safe limit above the conventional one-hundreth part of an inch.

With Mr. Conrad Beck's formula rigidly applied, we have the following table:—

Magnification.	N.A.	Focus of Objective with Eyepiece 10.
100	·20	16·0 mm.
200	·40	8·0 „
300	·60	5·33 „
400	·80	4·00 „
500	1·00	3·20 „

A power of four hundred and fifty would thus be the limit for dry objectives of ·90 N.A. The circle of confusion with this series would be the one hundred and ninetieth part of an inch.

With Mr. Nelson's formula we get:—

Magnification.	N.A.	Focus with Eyepiece 10.
100	·26	16·0 mm.
200	·52	8·0 „
300	·78	5·33 „
400	1·04	4·00 „

His circle of confusion would thus be the two hundred and forty-seventh part of an inch.

Comparison of the above with Professor Abbe's figures is not easy, since, as we have said, he decreases the power of the eyepiece as that of the objective increases, but no formula is given for the relationship between the two. They are simply the results of experiments made in 1874 on several objectives. Professor Abbe's paper was read on June 14th, 1882.

The following extract only from his table will suffice.

N.A.	Total magnification.	Magnification of eyepiece.	Magnification of objective.	Focus of objective.
·10	53	10·0	5·3	47·2 mm.
·20	106	8·2	12·8	19·4 „
·30	159	6·7	23·7	10·5 „
·40	212	5·6	37·9	6·6 „
·50	265	5·0	53·0	4·7 „
·60	317	4·6	68·9	3·6 „
·70	370	4·3	86·0	2·9 „
·80	423	4·1	103·2	2·42 „
·90	476	4·0	119·0	2·10 „

That this table does not agree with modern practice will probably be admitted. That modern objectives will bear higher eyepieces than the last six or seven of the table will probably also be allowed. This, however, is no fault in the table itself, which I cannot doubt was correct for most objectives of 1874. It is due to Professor Abbe himself that we are able to use new formulae for new objectives. The Abbe-Schott glass it is that enables the modern optician to make a dry one-tenth of an inch objective almost as perfect as the inch or the two-thirds of an inch. Professor Abbe's table shows us only the better the result of his investigations in both the theory and practice of the construction of objectives. Thus, we reject most of his tables as too low. We must reject Mr. Nelson's as too high. There remain Mr. Beck's and my own. The latter are, as I have explained, the minimum that can be adopted with safety, and some may prefer for a magnification of one hundred an aperture of ·15,

or even ·17, but the former would be ample for even "spotting" diatoms, giving a circle of confusion of about the one hundred and forty-third part of an inch.

The point to be noted above all is, that for good working distance and depth of focus the lower the angle the easier the work. Empty amplification is a great mistake, empty aperture is a greater, and much more expensive and equally valueless.

A four-millimetre objective, *e.g.*, of N.A. ·65 or ·74, is far more convenient than one of N.A. ·90 which will only work over No. 1 covers, whilst the former have working distances of a full millimetre. But the craze for "angle" is still with us, and many would rather take a quarter of an hour in coaxing a quarter-inch to resolve Angulatum than put on a one-twelfth inch and do it in one minute. Where, however, the student wants efficiency, convenience and moderation in price, he will get low angles for dry objectives based on N.A. ·15 per one hundred magnification. A one-sixth inch that will not work over any cover, even a No. 3, is a nuisance in a laboratory, and an unnecessary nuisance, too.

Meanwhile, opticians laugh in their sleeves and play to the gallery, and above all rake in the coin that foolish men throw away. If their clients will spend two pounds on a two-thirds where one pound would buy an equally useful one, or three pounds on the one-sixth where thirty shillings might have sufficed, they cannot complain. Meanwhile the student has wasted two pounds ten shillings: that is, half the cost of a good one-twelfth inch oil immersion which some day he must buy. Let him remember that useless aperture is a useless possession.

There is also another matter which these investigations bring out, and one which is of great practical importance, namely, the limit of useful magnification, and on this we must touch briefly.

At present the highest numerical aperture is 1·50. It will therefore be seen that if for every one hundred of magnification we allow a numerical aperture of ·20, the highest useful power will be seven hundred and fifty. Anything beyond that reveals no further structure, according to Mr. Conrad Beck's formula. With him agrees Professor Abbe. By Mr. Nelson's formula, the limit of useful power will be only $\frac{1\cdot50\times100}{\cdot26} = 577$, a much lower figure.

Let us now take facts. Most opticians make a two-millimetre semi-apochromatic of N.A. 1.30 at £5, and one of N.A. 1·40 at a varying price. They are, of course, oil immersions. The resolving power of the former is about one hundred and twenty-five thousand, and of the latter, one hundred and thirty-five thousand, as given in the tables. By photography these limits may be extended to one hundred and sixty-five thousand and one hundred and seventy-seven thousand eight hundred respectively.

The test diatom, *Amphipleura pellucida*, varies but slightly in its markings between ninety-five thousand and one hundred thousand lines per inch. It also varies a little in other ways, some being strongly marked, others being more feeble and difficult.

Now, we have several photographs of this diatom taken by acknowledged masters, with every appliance at their disposal. These photographs ought to show about thirty-three per cent. more than can be seen visually, so that what is not there in the photograph is almost certainly beyond the limits of ordinary vision.

In Dr. Spitta's "Microscopy," we have on Plate IV, Figure 2, a photo of the diatom with a Zeiss two-millimetre apochromatic of N.A. 1·30×750. This photograph, then, ought to show as much as the eye would see with the same objective, and under a magnification of one thousand. It shows fine lines only, and Dr. Spitta tells us in his text that this is what such an objective should show, and I do not for one moment doubt that this is all we ought fairly to expect. But notice, we have got above our theoretical limits of useful magnification and still get only lines shown.

In Messrs. Leitz's Catalogue of Photomicrographic Apparatus, another photograph is found taken with an apochromatic two-millimetre objective, the N.A. of which is not given, but is either 1·32 or 1·40. The magnification was one thousand one hundred and fifty, and a deep blue screen was used, needing an exposure of six minutes. This would give us as much as the naked eye, ×1400 or so. Still we get lines only, and again I insist that I do not doubt we see all that can be expected. There is a faint suspicion that the lines are serrated as if nearing resolution, but that is all we can say. But again notice, we have got to nearly twice the old theoretical limits of useful magnification and still get lines only.

We turn again to Dr. Spitta's volume, and on Plate VI, we find a magnificent photograph "taken (using blue light) with a Zeiss two-millimetre apochromat N.A. 1·40 × 2,800." He also notes that the dots are about the one-hundred-thousandth part of an inch diameter" and that "these are very difficult to see without the use of oblique green light, even when employing the finest objective. A first-class semi-apochromat should then show the dots furnishing an image almost as good as that afforded by the apochromat," and so on. I may add, the diatom is mounted in realgar, and is a picked specimen of the well-marked type. The magnification shows as much as one of three thousand five hundred does visually, *i.e.*, nearly seven times the old theoretical limit; and now we get fresh structure, namely dots.

Thus, the old theories must be revised, or at least modified; seven hundred and fifty is not the extreme limit of useful magnification. We may increase it to at least $\frac{1\cdot50\times100}{\cdot13} = 1{,}154$, or perhaps even to $\frac{1\cdot50\times100}{\cdot10} = 1{,}500$, with advantage. Our objectives will in this latter case be of much lower aperture, especially compared with the focus, but this is no difficulty, and the wise student will still use a low aperture for the usual two-thirds (sixteen-millimetre) objective, one of N.A. ·65 to ·75 for the one-sixth inch (4·2-millimetre), and one of as high as he can afford for the one-twelfth inch (two-millimetre) oil immersion. From the last alone he will expect the utmost resolution. The others will show him all that the eye can see without unduly forcing them by high oculars, and altogether he will have a battery that will save his eyesight, his patience and his pocket, and that will, above all, never disappoint him or fail to show him all that can be shown.

The specialist may go a step further and obtain a one-sixteenth inch oil immersion for the very highest power, not in place of the one-twelfth inch, but to supplement it and to prevent the use of too high an eyepiece. But it will be a luxury and not a necessity—a specialist's motor compared to the general practitioner's gig. For general work he will find low apertures and medium eyepieces give him everything that he can wish, and that the craze for higher apertures is the mark of the dilettante and not of the worker, of the ignoramus and not of the savant.

E. ARDRON HUTTON, M.A.

PHOTOGRAPHY.

By EDGAR SENIOR.

PHOTOGRAPHY WITH A PIN-HOLE. — Having for some time past devoted a considerable amount of attention to the above, it was thought that the subject might be found interesting to readers of "KNOWLEDGE" generally, as well as to those in search of methods, more or less novel, for obtaining photographs. Of course, it is not for one moment claimed that the definition given by a plain aperture—or so-called pin-hole—even approaches that of a high-class lens, yet the results are by no means fuzzy or blurred, as the illustration, Figure 67, from a pin-hole photograph taken by Mr. Alfred S. Gannon, the subject being "St. Brelade's Church, Jersey," testifies. Then again, as we do not in nature meet with that uncompromising sharpness which so many photographs exhibit—a plain aperture will, in many cases be found to give more artistic results, possessing those qualities termed by artists "atmosphere," "breadth of effect," and so on, and in the case of the photographing of buildings it is to be highly recommended, since the image will be an exact facsimile of the object, with an absence of that distortion so frequently seen in photographs

of a similar character. The one great drawback attending the use of a pin-hole in place of a lens is the protracted exposure necessary, which so limits its usefulness that, generally speaking, it is only in still-life subjects that its application is really possible. On the other hand, one of the advantages frequently claimed for the use of a plain aperture in place of a lens is the readiness with which the size of the image may be varied, merely by moving the plate nearer to, or further from it, without the definition appearing to suffer to any appreciable extent by so doing, the only alteration being in the amount of subject which is included, and which is dependent upon the relationship between the length of the plate and its distance from the aperture. Both theory and practice, however, agree in showing that the sharpest image is obtained when a definite relationship exists between the distance of plate and size of aperture, and although diminishing the aperture may improve the definition up to a certain point; beyond this the reverse would be the case, a result explainable on the undulatory theory of light. It therefore appears that the size of the aperture "for the best results" is regulated by the distance of the plate from it, and the wavelength of light employed in taking the photograph. We have before us as we write a photograph of a point of light taken with a pin-hole of one hundredth of an inch in diameter: the image is shown as a bright centre surrounded by eighteen alternately bright and dark bands (due to diffraction). A second photograph, taken with a larger aperture, shows an image of the same point of light, as a bright centre surrounded with only one dark band, with a faint indication of the formation of the first bright one. This photograph exhibits the limit to the size of the aperture for that particular distance of plate, as if it be diminished beyond this, each point in a luminous object would give rise to a spot surrounded by alternately bright and dark rings, which would impart a confused appearance to the photograph. The size of aperture that will give the best definition from fulfilling the above requirements has received the attention of more than one eminent writer, and is given by the equation:—

$$D = 2\sqrt{\lambda L}$$

where D is the diameter of aperture required, λ the wavelength of light, and L the distance of the plate from the aperture.

When employing light of maximum photographic activity the following formulae by Sir William Abney may be used:—

$$D = \frac{1}{120}\sqrt{L}$$

D and L being measured in inches. Taking nine inches as the distance of plate, the size of aperture would be found:—

$$\frac{\sqrt{9}}{120} = \frac{3}{120} = \frac{1}{40} \text{ inch.}$$

Table 16, giving the diameters of aperture best suited to the distance of plate, has been calculated from these formulae.

Diameter of Aperture.	Distance of the Plate.
$\frac{1}{60}$ inch.	4 inches.
$\frac{1}{50}$ inch.	6 inches.
$\frac{1}{40}$ inch.	9 inches.

TABLE 16.

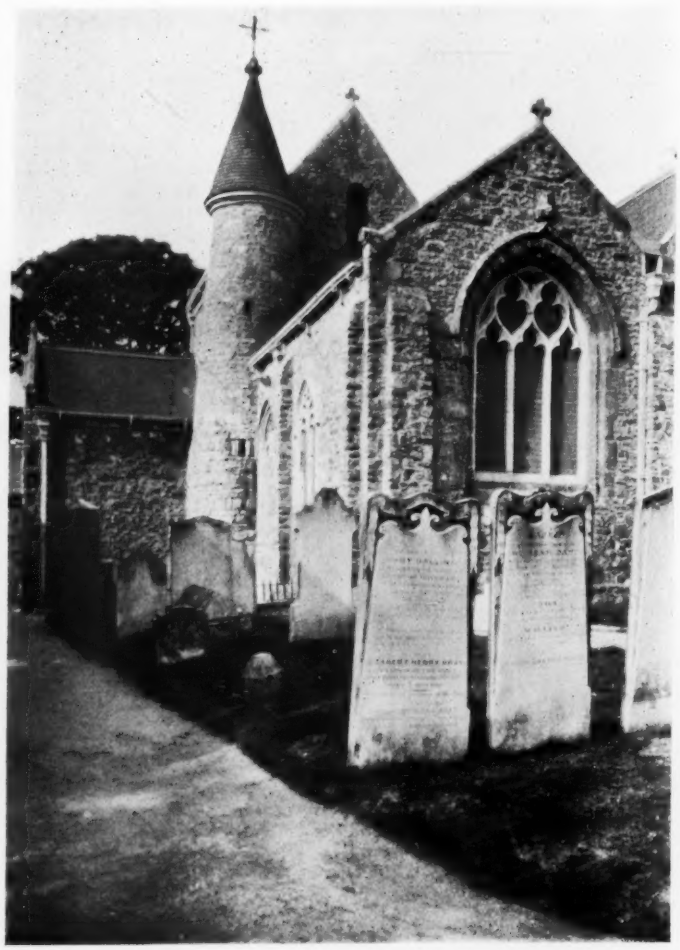


FIGURE 67. St. Brelade's, Jersey.

From a pin-hole photograph by Alfred S. Gannon. Diameter of aperture $\frac{1}{50}$-inch, distance of plate 6 inches, exposure 1½ minutes.

We now come to the question of the exposure required; but this need not present any real difficulty if we remember that the rule which governs it generally equally applies here, and that it may, therefore, be obtained from comparison with a lens aperture of known value. Thus, suppose it is desired to know what exposure is necessary to be given with an aperture of one-fiftieth inch in diameter, to a plate at six inches from it, in comparison with a lens of six inches focus and stop three-quarters of an inch in diameter (f/8). By the rule, the exposures would be as $(\frac{1}{50})^2$ to $(\frac{3}{4})^2$ or $2\frac{1}{500}$ to $\frac{9}{16}$, so that the plain aperture requires 1406·25 times longer exposure. Therefore, if the subject required one-fifteenth of a second when using the lens whose aperture was three-quarters of an inch in diameter, by substituting the pin-hole whose diameter was one-fiftieth of an inch, the required exposure would be one minute thirty-three and three-quarter seconds. It is therefore evident that the required exposures may be readily calculated from the intensity ratios of the apertures. In determining the exposure by this method, the distance of the plate should be the same in both cases, as the exposure required varies as the square of this distance.

In order to avoid any calculations at the time of taking the

photographs, it is advisable to draw up a table of the exposures required with plain apertures compared with those of a lens, when used under various conditions; such as speed of plate, condition of light, time of day, time of year, distance of object, and so on. With regard to the photographs themselves, they may be said to possess a charm peculiarly their own, while at the same time the method of production is of the most simple and inexpensive kind.

In making these apertures for use, the writer employs both brass and aluminium foil (preferably the former) as the material, piercing the holes by means of fine needles, care being taken that any slight burr round the edge is carefully removed by rubbing on an oil-stone, so that there is no appreciable edge to interfere with the passage of light through them. By examination from time to time under a microscope of moderate power their condition is observed, and when satisfactory the aperture is measured, and the foil containing it mounted up in a frame of blackened card for use.

ZOÖLOGY.

By PROFESSOR J. ARTHUR THOMSON, M.A.

PROPORTIONS OF SEXES IN EARWIG.—H. H. Brindley finds that the proportions of the sexes differ considerably in different localities in the same year and sometimes differ considerably in localities quite near each other. The proportions may differ appreciably in the same locality in different years. This may be due to variation in the extent to which the males survive the winter. There is a slight suggestion that the percentage of males is higher on small islands. The evidence that the characters of the soil or vegetation or altitude affect the proportions of the sexes is exceedingly slight. The normal length of life of earwigs is unknown. Adult males are found somewhat rarely in the early months of the year.

COLOUR OF FISHES.—The epidermis of fishes is delicate and transparent. All the colour is in the dermis, and it usually occurs in separate pigment-cells. These usually show numerous radiating processes, and the pigment can be spread out over a large surface or concentrated in the centre. This depends on the expansion or contraction of the mobile protoplasm of the pigment-cells. According to the pigment they contain,—black, or yellow, red, and so on—the pigment-cells are called melanophores, zanthophores, erythrophores, and so on. Then there are other cells containing spangles of the waste-product guanin, which are called iridocytes or guanophores. They cause the silvery, metallic, or iridescent appearance familiar on many fishes. But Professor Ballowitz has recently discovered in the weaver and some other bony fish, a new kind of chromatophore, not a single cell, but a group of cells. Each melaniridosome, as he calls them, is a cluster of iridocytes with an encapsuled central melanophore, which sends its ramifying processes through the capsule in complicated courses.

PARENTAL CARE AMONG ANTARCTIC ECHINODERMS.—It is well-known to zoölogists that many of the Antarctic sea-urchins, sea-cucumbers, and other Echinoderms show parental care, keeping their young ones sheltered about their bodies and that in a striking variety of different ways. Professor Ludwig has recorded ten cases of parental care in Echinoderms from warm waters, and twenty-nine from the Antarctic. Out of twenty-four different species of coastal sea-urchins from the Antarctic, Mortensen reports that no fewer than fourteen show parental care, and eleven of these are littoral. The puzzle is why this habit, which is rare among Echinoderms as a class, should be so common in the Antarctic. An answer has been suggested by Hjalmar Ostergren (*Zeitschrift wiss. Zool. C.* 1912). He points out, first of all, that the numerous sea-cucumbers which exhibit parental care in the Antarctic, belong to families which are known elsewhere to exhibit the same peculiarity. He points out, in the second place, that the distribution of land and water in the south is quite different from that in the north, and that for coastal Echinoderms everything is against the success of free-swimming larvae. The low temperature of the water and its low salinity tend to bring about a shortening of the life-history or at least a suppression of free-swimming larval stages. In point of fact, only three or four cases of free-swimming Echinoderm larvae are known from Antarctic seas.

CORRESPONDENCE.

SQUARING THE CIRCLE.

To the Editors of "KNOWLEDGE."

SIRS,—In a letter in the November issue of "KNOWLEDGE," "Geoma" gives a method of "squaring the circle," stating that the perimeter of a circle of unit diameter is equal to that of a certain triangle. This amounts to no more than the statement that $\pi = \sqrt{5}+1$ approximately. This is not in itself a good approximation to the value of π and it would be quite easy to draw a triangle whose perimeter gave a much closer approximation. But, however close the approximation, we should be no nearer "squaring the circle" by geometrical methods.

3, ST. JOHN'S ROAD, OXFORD. R. J. POCOCK.

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—Referring to recent letters on this subject which have appeared in "KNOWLEDGE," I have been rather struck by the fact that few of your correspondents seem to have clearly distinguished between what is possible, what is imaginable, and what has a real physical analogy and bearing. The argument that the existence of one or two dimensions implies a third, and the third implies a fourth, and so on *ad infinitum*, seems to me utterly without value from the following very simple consideration. Objects and space of one and two dimensions only *are purely mental* abstractions. All bodies to be seen at all or even clearly apprehended, in my mind, must have three dimensions, neither more nor less. The geometrical point must have some bigness, some (however small) depth; the line must have at least a slight breadth and thickness (*i.e., three* dimensions, though one greatly predominates, and the others may be disregarded *except the fact of their existence*). It is a result of *experience* that three numbers are, in general, necessary to define the position of any point with regard to any other; in algebraical language, the x, y, and z coördinates. If one of these coördinates, say the z, be, or *is assumed to be*, the same for all points, we have the x and y coördinates only, the coördinates of *plane* geometry, and lastly, for a common y we have all the *ideal* points lying on a straight line (the axis of x or any straight line parallel to it in the plane xy, $z = 0$ *or C*). This, in common sense language, is *all* that the whole thing means, as we have pointed out elsewhere (*Quest, English Mechanic*, and so on).

By the algebraical methods of coördinate geometry a vast body of geometrical theorems has been shown to have algebraical parallels, and conversely, theorems applying to curves and surfaces in general have been discovered by the application of analysis to the coördinates x, y, and z. It is possible (and has actually been done) to introduce a fourth coördinate, w, or, indeed, any number of fresh coördinates, and by algebraical methods to deduce theorems of great beauty and interest, but the results will have no *geometrical*

XUM

parallels. Some mathematicians have even discussed some problems of motion, using the three coördinates, x, y, and z, and the fourth w to represent a fourth dimension, and their results are given in dynamical works, just as we find problems as to the motion of bodies under laws of force differing from that of nature (inverse cube, inverse fifth power, direct distance, and so on) set for the edification and *amusement* of students. Of a somewhat different character is the question as to the *curvature of space*, which, *we are told*, may possibly be *some day* detected by astronomical observations. At present, however, we find that the Euclidian "homaloidal" space agrees most closely with the space of *experience* and is the simplest concept, but there are other concepts which within the limits of observational error give results differing but little therefrom. If some day the existence, say, of stars with negative parallaxes be definitely ascertained "lying on the other side of nowhere," some mathematicians may regard this as a proof of the non-Euclidian nature of our space, but meanwhile astronomers generally will be likely to find a simpler explanation.

WALTHAMSTOW. F. W. HENKEL, B.A., F.R.A.S.

THE FOURTH DIMENSION.

To the Editors of "KNOWLEDGE."

SIRS,—I notice in the November number of "KNOWLEDGE," that Mr. John Johnston still continues the (as I think) unprofitable exercise of criticising a theory, with the arguments for which he has not taken the trouble to acquaint himself. Mr. Johnston says that "Our experience of dimensions gives us the law that where there is one there must be three, but it gives us absolutely nothing else. There is nothing in it to lead us to believe, or even to suggest to us, that there are other dimensions." On the other hand, I say that the existence of any number of dimensions (say n) implies the existence of one more dimension $(n+1)$, and so on, *ad infinitum*. In support of that statement I have brought forward certain arguments, to which I have referred Mr. Johnston. Now, these arguments of mine may involve a fallacy. I may have misapplied the principle of the continuity of natural law, or committed some other logical mistake. If so, I am quite willing to relinquish a belief in the real existence of the fourth and higher dimensions; since this belief does not form an integral part of my philosophy, but is merely an appendage thereto, supported only by its own specific arguments. But if this be the case, let Mr. Johnston point out the fallacy in my argument; not content himself with making bland assertions and negations without first finding out what this argument is. If Mr. Johnston does not wish to do this, then let the correspondence cease, since it is only a waste of time and the valuable space of your journal; for I must confess I am not sufficiently anxious to convince Mr. Johnston of the correctness of my views as to the fourth dimension to the extent either of restating them in a letter, or of sending Mr. Johnston a gratuitous copy of my book.

H. STANLEY REDGROVE.

THE POLYTECHNIC,
REGENT STREET, LONDON, W.

P.S.—Reading Mr. Johnston's letter my eye caught that of its companion signed "Geoma." I thought that Professor De Morgan had annihilated the last circle-squarers, and that the species was now extinct. "Geoma" may easily satisfy himself of the inaccuracy of his "theorem" by measuring the diameter of a cylinder with calipers and its circumference with thread, since it is quite easy to get the value of the ratio (π) by this means correct to two places of decimals: that is, 3·14. Of course, as I expect all your readers know, it has been *conclusively* proved by the higher mathematics that the value of this ratio is an incommensurable quantity, and that to five places of decimals its value is 3·14159.

A BAROGRAPH RECORD.

To the Editors of "KNOWLEDGE."

SIRS,—The wet weather we have experienced since the 15th of July, though that day was fine and bright with us, is, probably, a fair sample of the kind of weather that originated the legend of St. Swithin.

My Barograph has been comparatively unchanged during this period of rain and wind, but the accompanying record (see Figure 68) of a thunderstorm here on the night of May 11th and 12th last, is quite unprecedented during the last ten years and may be worth notice in your columns.

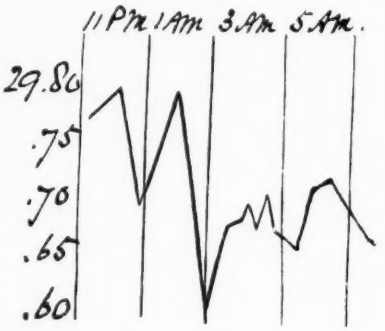


FIGURE 68.

JOHN GLAS. SANDEMAN.

WHIN-HURST, HAYLING ISLAND.

ON COOKED FOODS.

To the Editors of "KNOWLEDGE."

SIRS,—I read with much interest, the article in the October number of "KNOWLEDGE," by Katharine I. Williams, but would like to ask how her values would stand if the vegetables were cooked conservatively and did not come in contact with the water in the process.

It is not denied that the old-fashioned method of cooking vegetables is wasteful and foolish in the extreme.

A. GAUBERT.

13, SHAFTESBURY ROAD,
HORNSEY RISE, N.

SCHOOL SCIENCE SOCIETIES.

ONE of the topics discussed by the Association of Public School Science Masters at their meeting, held at the London Day Training College, on the 8th and 9th of January, was the aims and uses of School Science Societies. The general principles were dealt with by Mr. W. M. Hooton, of Repton, and after considering the general advantages of such societies and their kinds, he spoke of the limitations imposed by organised games, which, very many will agree, stand greatly in the way of the boy whose tastes and inclinations would lead him to acquire knowledge first hand and in his own way. Mr. Hooton emphasised the point that, in his opinion, organised games did not so much use up the time of the boys as their energy, and left them too tired for other pursuits. In either case the result is the same. With all due respect to Mr. Hooton's contention, we think that a trustworthy boy who would prefer taking a ramble in order to study some scientific subject as a hobby, to playing games should be allowed to do so. Mr. Hooton also testified to the good training obtained by boys in preparing lectures and illustrations. Mr. F. C. Headley, of Haileybury, when discussing School Natural History Societies, dwelt on the need for unspoilt country to be within easy reach. He said that at private schools many boys with a definite bent for Natural History had the enthusiasm starved out of them. Liberty and leisure, he claimed, were important things. Some of the leading boys should be enlisted as supporters, and it should be made clear to them that Natural History leads on to the study of evolution and to many difficult problems, and is not merely an amusement for little boys.

Geological Societies were advocated by Mr. C. I. Gardiner, of Cheltenham; Photographic Societies, by Mr. T. H. Oldham, of Dulwich, and Astronomical Societies by Mr. G. Hewlett, of Rugby.

SOLAR DISTURBANCES DURING DECEMBER, 1912.

By FRANK C. DENNETT.

December was very cloudy, and hence the record is somewhat imperfect, no less than eleven days having been missed completely. On six days (2, 3, 8, 9, 10, and 28), the disc was apparently free from disturbance, and on one, the 23rd, only faculae were seen, spots being visible on the remaining thirteen. The longitude of the central meridian at noon on December the 1st, was 54° 36′.

No. 24.—First seen in a faculic disturbance a little way on the disc from the eastern limb on the 12th, a spot with tiny pores, some before and some behind it. On the 16th it showed two distinct umbrae. The larger spot had seemingly broken into two next day, and on the 18th was much less conspicuous, not being seen after.

No. 24*a*.—This disturbance, certainly connected with the last, appeared some 50,000 miles in front of it, on the 16th—if not on the 15th—a spot with some pores round. On the 17th two dark penumbral spots had developed almost midway between the southern components. On the 18th the rear spot of this group had formed, nearly equal to the leader. On the 20th, both these spots were still visible, but on the 22nd only the leader remained amongst a quantity of faculic matter, whilst this spot was not to be seen on the 23rd, only the faculic remains of the outbreak. The length of No. 24 was 30,000 miles, *a*. 45,000, and the double group 82,000 miles.

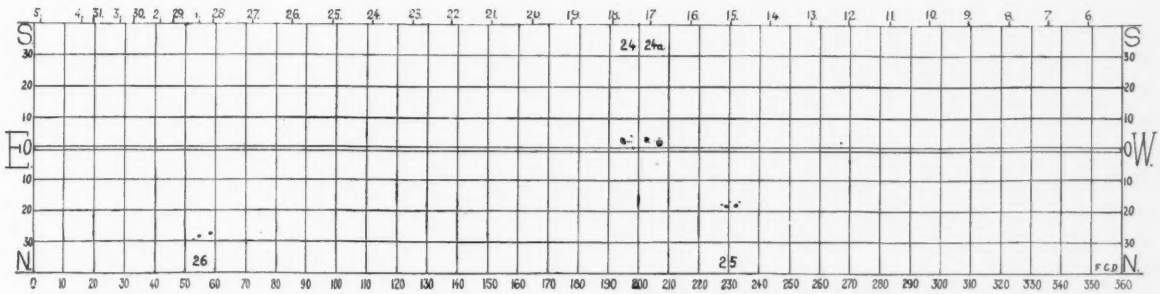
No. 25.—A group of spotlets and pores, 35,000 miles in length, seen on December the 17th, only one of which, the leader, was found next day. Its place was marked on the 20th by a faculic area.

No. 26.—A group of spotlets and pores, 46,000 miles in length, first seen on the 29th, which changed its appearance considerably during its visibility, being last seen amid faculae close to the north-western limb on January 3rd.

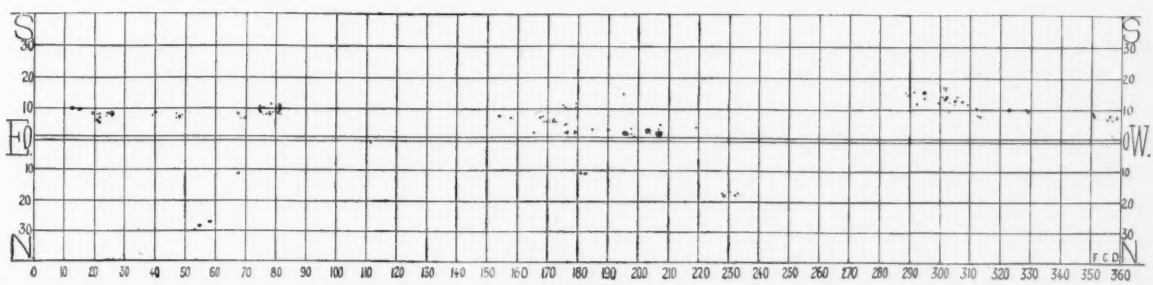
During the past year only 27 outbreaks of spots have been recorded, one being of a secondary character. Of these, 22 have appeared in the southern hemisphere, and only five in the northern. It is somewhat singular that in December, 1911, a little disturbance broke out in 23° N. Latitude, and now again in December, two disturbances have made themselves visible, one in 17°, the other in 27° N. Latitude. These may prove to be the forerunners of a new cycle of solar phenomena. The second chart shows the distribution of the spot disturbances during the year. The collection of disturbances into groups is again a noticeable feature in the southern hemisphere. One chain of activity extends from 350° to 82°, and another from 153° to 220°, and a third from 228° to 330°, many of the second group drawing very near the equator. Of the 333 days upon which the Sun has been observed, spots were recorded on 108, faculae were seen on 99, whilst on the remaining 126 the disc presented an unruffled surface.

Our monthly chart is from the combined observations of Messrs. J. McHarg, A. A. Buss, E. E. Peacock, W. H. Izzard, and the writer.

DAY OF DECEMBER, 1912.



DISTRIBUTION OF SPOT-DISTURBANCES DURING 1912.



SOME EFFECTS OF THE HOT, DRY SUMMER OF 1911

By LIONEL E. ADAMS, B.A.

IT was natural to expect that the exceptional tropical heat and the drought of the summer of 1911 should produce some effect on the fauna and flora of our island, which is only at rare intervals subjected to such conditions, and this expectation has been fulfilled.

Perhaps the most noticeable feature of the season was the phenomenal abundance of wasps. On August 16th a neighbouring keeper and I took sixteen nests in two fields, through which the river Mole flows. By the way, the quickest and altogether most effective method of taking wasps' nests is by means of a solution of two ounces of cyanide of potassium to one and a half pints of *hot* water, cold water failing to dissolve the cyanide. One pound of cyanide costs three shillings at the chemist's, which amount will make enough solution for fifty nests. A wineglassful should be poured into the entrance holes of the nests. Then watch—you will see the wasps continue to come in for an hour or two, but *vestigia nulla retrorsum*. When all have entered, the nest may be safely dug out; but if left till the next day the fumes of the poison will have evaporated, and the wasps hatched after that will be found alive and stinging. A great advantage of this method is that it can be carried out in daylight and without much danger of being stung.

In contrast to the abundance of wasps was the comparative scarcity of flies. This was due to two causes; first, they are the prey of wasps, but perhaps more especially because the drought had deprived the manure and refuse heaps of the moisture necessary for the well-being of the fly larvae.

A great abundance of the Peppercorn Oak-gall was noticed in Surrey by Sir Jonathan Hutchinson and Dr. T. A. Chapman, and recorded by the latter in the September number of the *Entomologists' Record and Journal of Variation*.

In the same number Dr. Chapman and other entomologists record an unusual abundance of *Pieris rapae*, the Small White Butterfly, and also an unusual proportion of small individuals of this species as well as of *P. napi*. Dr. Chapman explains that this dwarfing is caused by the heat forcing the larvae to maturity and pupation before they had time to eat enough to grow to their normal size, and not by any deficiency of food.

Also, in the same number of the journal, another observer notices an insufficient colour supply and albinism whole and partial in the genus *Colias* in Switzerland.

In certain gardens in Reigate there was practically no aphis, though their enemy, the ladybird, was also scarce.

Owing to the drought land snails on which the thrushes feed remained in hiding, and a friend of mine found in Northamptonshire several thrush "anvils" (that is, stones on which the birds break the shells to extract the animal) surrounded by broken shells of the large water snail, *Limnae stagnalis*—a most unusual food of thrushes.

The keeper above referred to, and some of the neighbouring farmers, informed me during the drought, that they found thrushes and other birds dead, presumably on account of scarcity of worms and slugs.

I fully expected to find an unusual number of dead shrews along the roads and lanes, but to my surprise I found far fewer than usual. However, as I happened to be trapping shrews throughout the summer and autumn a great number passed through my hands, and I noticed that their coats were markedly paler than usual, and that about twenty-five per cent. had white ears, whereas the normal percentage of white-eared specimens is four or less.

Moles were affected by the drought in a curious manner. From three different sources I heard the same story of dead moles being found about the lanes and fields in large numbers. These had died of starvation.

One farmer of a hundred acres made a practice of going out with his dogs at night to hunt moles, and killed over a hundred in this way. It is usual for moles to come to the surface during the nights of summer and early autumn after worms; but last season they fared badly in two ways—worms were scarce from want of dew and rain, and, moreover, the ground was caked hard and difficult for worms to work through. Also, when once above ground, the moles found a similar difficulty in burrowing out of sight before their enemies were upon them.

In our Reigate garden and all round the neighbourhood the Jerusalum artichokes (*Helianthus tuberosus*) blossomed.

Early in August the leaves of various trees turned yellow and began to fall. The bracken began to fade at the same time, and by August 20th there were several large patches of dead bracken on the heaths in Surrey.

During the present year Yuccas have been abnormally prolific in bloom, and one of the gardeners at the town's public gardens attributes this to the heat of last year "ripening them up."

A paradoxical incident occurred which was exceedingly puzzling till the probable explanation occurred to me. Two springs which had run dry at the beginning of August started running again at the end of the month, although there had been no more rain. I could only account for this by supposing that more cracks had gone on developing in the dry ground till water was reached further back in the water-bearing bed.

THE PROBLEM OF THE MOON'S ORIGIN.

By B. G. HARRISON, F.R.A.S.

THE air of mystery which always enshrouds the Moon compels even the most unreflective of us to speculate upon its past history. A world devoid of life, one pictures the vast upheavals and intense convulsions that must have taken place to have moulded the landscape into its present chaotic form, which bears witness to its former tempestuous existence. Seen through the telescope, one is impressed by the sense of utter loneliness and desolation that seems to prevail everywhere, while the apparent permanence of each feature on the lunar surface makes one wonder how long this changeless aspect has continued. Indeed, there are few problems connected with astronomy so fascinating as that of the origin of our satellite, more especially since any knowledge of its past would be of infinite assistance in helping us to frame the general theory of cosmical evolution.

Apart from the fact that the Moon is our nearest neighbour and the most familiar of all the celestial bodies, the evidence of its formation is considered to be of a far more conflicting nature than in the case of any other portion of the solar system, and for this reason alone presents features of the greatest interest.

There are, of course, only two ways in which our satellite could have attained its present position. It may once have been a minor planet which ventured too near the Earth and was consequently captured by the latter; or else it must at some remote period have formed part of our globe and have been separated from it by rapidity of rotation. Before considering these alternatives in detail it will be perhaps as well briefly to outline the most usually accepted hypothesis of planetary evolution.

The general features of Laplace's celebrated nebular theory are well known. This illustrious mathematician suggested that our system was originally a nebulous cloud or "firemist" of glowing gas, which gradually contracted, throwing off rings in the process. From these rings the planets were evolved and the nucleus eventually condensed to form our sun. Laplace himself advanced this theory with considerable mistrust, and recent research has caused several modifications to be made in his hypothesis.

In the first place, the original high temperature with which he endowed his nebula is now considered unnecessary. It is realised that the actual contraction of the gaseous mass would provide all the heat required to account for the present observed temperature of the sun and planets, even after due allowance is made for loss by radiation entailed in the process. Secondly, it is thought very improbable that the nebula could ever have had a sufficiently rapid rotation to detach the rings. Even if these were detached, the result has not been quite what we should expect. Theory demands that the width of these rings should be infinitesimal, since otherwise the outer portion would revolve more rapidly than the inner and thus upset their dynamical equilibrium. As the acceleration of rotation would probably proceed at a uniform rate there should have been a vast number of these situated at intervals bearing a fixed ratio to each other, thus giving the transformed nebula a perfectly symmetrical appearance. Even if it were possible for the rings to condense into planets, which seems doubtful, we should expect their masses to bear a more constant proportion to one another than is actually the case. Perhaps a still more unfavourable argument to this idea of our system's development lies in the fact that amongst the vast numbers of nebulae which have been discovered, none afford any convincing evidence of concentric ring formation.

It is generally far more easy to detect faults in the theories of others than to provide a thoroughly satisfactory hypothesis in their place, and critics have found the case in point no exception to the rule. Nevertheless, numerous suggestions of more or less merit have been advanced from time to time, but as space will not permit of their consideration in detail, we will confine ourselves to outlining what is perhaps the most feasible theory of planetary evolution. To do this it will be necessary to go back an epoch further than Laplace did, and consider the actual formation of the primordial nebula. It is thought probable that this was caused by the near approach of another star to our sun, which at that remote period may have been simply a dark body. It is by no means necessary for an actual collision to have taken place, since the disruptive action caused by the different portions of each sphere being at varying distances from the common centre of gravity, and thus being pulled with unequal force, may have been quite sufficient to tear them both apart and scatter a portion of their contents into surrounding space.

Now there are three possible courses for matter thus ejected to pursue. Either to follow a path by which no return to the system would ever be possible, to fall back to the Sun itself, or to revolve around him in elliptical orbits. If our luminary were travelling in a straight line, and in the absence of any other perturbing force, all matter would follow one of the first two courses, according to the force of ejection. It is necessary, therefore, to assume that either owing to the action of the disturbing stranger, or else through collisions amongst themselves, the paths of some of the particles were altered, and they were forced to permanently revolve round the Sun, thus forming our embryo solar system. It is probable, in any case, that a large proportion must have followed one of the other alternatives, and so have either increased

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the temperature of our luminary, or else have been lost to the system for ever.

We imagine that the Sun was rotating before the initial catastrophe occurred, since this motion would give a preponderance of direct revolution amongst the ejected particles, although it is likely that that of a large percentage may have been retrograde. This diversity of motion would naturally cause frequent collisions, and in this way other small centres of gravity would gradually be formed. As these centres increased in size, their attraction would deflect neighbouring particles from their original course and cause them to revolve round them. Further collisions would ensue amongst the captured fragments, involving a consequent loss of energy, and they would thus be slowly drawn nearer to, and finally upon, their various centres of attraction, while the dismembered remains of the original sun, being in the centre of the nebula, would succeed, owing to their superior mass, in gathering up the greatest portion of the scattered contents.

We may thus endeavour to picture to ourselves our system slowly evolving, a vast aggregation of particles of various sizes, extending far beyond the present orbit of Neptune and becoming more and more scattered as the distance from the common centre increased. Occasionally we should witness the collision of two fragments, and the consequent generation of light and heat, and we should also observe the increased frequency and violence of these collisions in the vicinity of the Sun. Although individually presenting every diversity of movement, these particles would in the aggregate present a certain orderly sequence, and a series of vortices would be noticeable revolving round the Sun in the same direction as its own rotation, the larger ones lying in substantially the same plane: that of the disturbing star's approach. The general appearance of the system would closely resemble the spiral type of nebulae which have been revealed to us in such numbers by the telescope and the photographic plate in recent years. It is a significant fact that all these nebulae consist of two arms emanating from a central nucleus at diametrically opposite points. So far as we are aware the only force capable of producing this symmetrical appearance is that of disruptive tidal action, since, were the coils thrown off owing to rapidity of rotation, jets of matter would be ejected from every part of the circumference, and if by explosive force from indiscriminate points on the surface.

This, then, is the modern idea of the primordial nebula, a somewhat different one from the conception of Laplace, insomuch as it consists of independent particles revolving round a common centre of gravity in elliptical orbits instead of a slowly rotating sphere of glowing gas. It also has this advantage, in that it presents a complete cycle of events, from star to nebula and from nebula to star. This is analogous in our conception of the infinite to the difference between a circular and a straight line. There is less difficulty in imagining the former as endless than the latter, although the origin of either may be equally incomprehensible to our finite minds.

It must not be imagined that the hypothesis here outlined is entirely satisfactory, but as there appear to be fewer drawbacks attached to its acceptance than to that of most of the theories that have been advanced from time to time, it is generally considered probable that our evolution proceeded somewhat on these lines. Accordingly, it would appear natural that the planets and their satellites were both formed by the capture and aggregation of smaller particles in the same way. The lesser whorls would control the particles in their immediate vicinity, but would themselves be under the attraction of the larger vortices, just as these would in their turn be controlled by the Sun.

It is, of course, mathematically impossible for one body to capture another without the intervention of a third force. This may be illustrated by the case of a comet approaching our solar system. If the former is a wanderer from interstellar space it is obvious that although the solar attraction will enormously increase its velocity as it draws nearer, after the comet has passed perihelion, the Sun will only be capable of controlling the same speed as it was able to impart, and the visitor will leave the confines of the solar system with its original momentum unimpaired. If, however, the comet passes near one of the planets, the attraction of the latter may more than counterbalance the initial velocity of the comet, and thus change its hyperbolic orbit into an elliptical one. Another means whereby a portion of the wanderer's energy could be dissipated is by moving through a resisting medium. This is a more satisfactory method of accounting for the capture of a satellite than by means of a third attractive force, since the latter would as often free the satellite from the control of its primary, as assist in making it captive.

The capture theory, therefore, demands as a necessary condition the existence, at all events in the past, of a resisting medium. Professor See, to whom the development of this hypothesis is due, considers, and not without reason, that the presence of this medium was very probable. For it is almost certain that the vast quantity of gases which would have been liberated with the more solid matter at the birth of our solar system, would have existed in the free state as a nebulous cloud for untold aeons before combining with these solid elements, or forming the atmospheres of the various worlds in the course of evolution. This would render it possible for a satellite entering the sphere of a planet's influence to be eventually retained by the latter, and would also have the effect of decreasing the satellite's orbit. It would at the same time cause an eccentric path to become more circular, since a circle encloses a larger space than any other curved line of equal length, and a body can consequently revolve round a certain area with less expenditure of energy if moving in a circular orbit than if travelling in one of any other form.

Now, the sphere of the Earth's influence extends to a distance of over nine hundred thousand miles, so that any small body revolving within this distance would be entirely under the Earth's control, and since the Moon is less than two hundred and forty thousand miles away, its position, and the circularity of its orbit, could most easily be accounted for by this supposition. The same remark applies to all the known satellites of the other planets, which are in every case well within the space controlled by their respective primaries, and which, with the exception of the outer ones of Jupiter and Saturn, have remarkably circular orbits.

Owing to the unique nature of the Saturnian system it has frequently been typified as an example of cosmical evolution. Thus, at the time when Kant and Laplace framed their theories, the rings were thought to consist of gas, and, therefore, to corroborate them. The rings have since that time been conclusively proved to be formed of vast numbers of independent particles revolving round their primary, but were still considered to be a satellite in course of formation. Edouard Roche, a French mathematician, has, however, shown that it is impossible for a satellite to exist within 2·44 radii of its primary, owing to the strain imposed by the attraction of the latter. It is, therefore, probable that if a resisting medium exists in the solar system, a satellite may have actually been brought by its influence within the proscribed area and been torn to pieces, the rings thus being an example of the end rather than the birth of a world.

The thesis of possession by capture would consequently account for the presence of the satellites under the control of their various primaries in the most likely manner. Indeed, were it not for the conflicting testimony offered by our Moon, there could be but little diversity of opinion on the subject. It will be as well, therefore, to examine the evidence regarding our own domestic system somewhat more fully. There is, of course, only one other possible way to account for the present position of our satellite, which, if it has not been captured, must have been formed by fission of the Earth, and this latter theory seems to have met with almost universal acceptance ever since the time of Anaxagoras, 500 B.C. Now, there is one unusual feature about the Earth-Moon system favourable to this hypothesis, namely, the relative sizes of its two constituents, which are in the ratio of eighty-one to one. If we except Neptune and his satellite, about which some doubt exists, the nearest approach to equal masses in the other planetary systems is to be found in that of Saturn. His largest satellite, Titan, is but the one four thousand seven-hundredth part of his mass, and there is a still greater discrepancy in the relative sizes of all the other satellites to their primaries. This peculiarity of our Moon might, therefore, seem to imply a different origin from that of other satellites, although, if it ever revolved against resistance, there is no dynamical reason why our Earth should not have captured such a comparatively large globe.

There are, however, several objections to the fission theory. In the first place, it would be necessary for the Earth to have attained a sufficiently rapid rotation to have overcome the force of gravity by centrifugal force. The alternative to this would be to assume that the rupture was caused by tidal strains, in the same way as that suggested in the evolution of the solar system. Now, if this had happened, two streams of matter would have been ejected and formed a small spiral nebula. It is extremely unlikely that all the meteorites forming the coils would have only condensed into one other body, since we should expect a miniature solar system of our own, with some satellites considerably nearer than the lunar orbit, and others further off. Moreover, the presence of the disturbing element would have to be accounted for. Unlike the strange star which is supposed to have caused the birth of the primordial nebula, this second sphere would probably be unable to escape from the control of the Sun, and as it would necessarily be of considerable size to cause the requisite amount of damage, its presence could almost certainly be detected; for even were it now beyond the range of our telescopes, we should in all likelihood notice its perturbing effect on the outer planets. As we know of no such body, we are forced to discard this surmise and fall back upon a rapid rotation as the only cause of fission.

It has been calculated that, in order to overcome the adhesion of its particles by centrifugal force, our planet would have to possess an axial rotation of two hours and forty-one minutes. The only means of obtaining this enormous velocity would be by contraction from a nebulous condition. To appreciate this process it is necessary to understand what is involved in the term "moment of momentum." It is well known that momentum is the product of the mass and velocity of a body, and "moment of momentum" denotes its rotary power round an axis. If we neglect outside influence it is manifestly impossible to alter its amount in a rotating body, however much the latter expands or contracts. Whatever it loses, therefore, in decreasing size, is compensated by an increase in angular velocity, or in other words, in a contracting body, rotating freely in space, the angular velocity varies inversely as the square of the radius.

Now, this increase is considerably in excess of the additional speed required by the particles of a body to counteract the increase of centripetal force, due to their nearer approach to the centre of gravity. Thus, although the Earth is thirty times nearer the Sun than the planet Neptune, its angular orbital velocity is only one hundred and sixty-five times that of the latter, whereas the contraction of a rotating sphere to one-thirtieth of its original diameter would result in an increase of 30^2 or nine hundred times its initial angular speed.

If, therefore, the Earth were sufficiently diffuse, and its original rotational velocity were rapid enough, it

would be quite possible for it to disintegrate when sufficiently contracted. Unfortunately, we cannot be at all certain that the rotation of the Earth has ever been much more rapid than at present; although, could any evidence be advanced in its favour, it would remove one of the greatest objections to the fission theory. It might be expected that the earth would still show some signs of the distortion of its surface which a more rapid rotation would involve; but it is rather significant that no facts of any convincing nature exist to testify to this either in physics or geology. It is, of course, possible that time may have obliterated any evidence that has been left us, but it is by no means certain to have done so.

Although this is not a very conclusive argument it is nevertheless unfavourable to the idea of a rapid rotation, and if we examine the other members of the solar system for any evidence regarding the original length of our day, the result is equally unsatisfactory.

(To be continued.)

REVIEWS.

ANTHROPOLOGY.

Malta and the Mediterranean Race.—By R. N. BRADLEY. 336 pages. 1 Map, 54 Illustrations. 9-in.×6-in.

(T. Fisher Unwin. Price 8/6 net.)

Mr. Bradley's book is crammed full of interesting facts, contentions, and suggestions, and bears out Professor Sergi's theories to a very considerable extent. From a glance at the title one might think that the work had little relation to our own country, but it would seem that English people are largely of the Mediterranean race, though by no means of so pure a type as the existing Maltese; but it is said that judging only from the looks of the men and women with grey or blue eyes, one might imagine oneself in Ireland instead of Malta. The chapter showing the traces of the Semitic language which are to be found in our own is particularly important, and the illustrations given by no means exhaust the results of Mr. Bradley's researches. The "ash" tree has the same name in Arabic and comes from the word ash, meaning "to nest," as it is a favourite nesting tree; "dally" is from the Arabic "dall" to be coquetish with; "merry" is not much changed from the Arabic "marih," to be lively. The Arabic "silak" meaning spun thread, by the loss of the "a" becomes "silk," and in the same way "atan," to macerate hides, becomes "tan." Mr. Bradley goes carefully into the monuments of Malta, the dolmens, which he looks upon as imitation caves, and the secondary burial of human bones after the removal of the flesh, common to Malta, Sicily, Crete, and Ancient Egypt. There is also much attractive matter with regard to designs, to ladies' dress, to the characteristics of the ancient and the modern Maltese, and that in times gone by, as at present, stout people were admired is shown by the discovery of steatopygous figures. The connection between Kaffirs and the more northern peoples which gave rise to the Mediterranean race is discussed, and allusions made to the votive axe in stone and copper, which is common throughout the Mediterranean. The examples of polished axe amulets seen in Figure 68, which we have borrowed, are from Malta.

By the courtesy of *Mr. Fisher Unwin.*

FIGURE 68.

Polished Axe Amulets of Hal Safliena, Valletta Museum.
(From "Malta and the Mediterranean Race.")

Mr. Bradley shows, from an examination of old and recent skulls, that the Maltese were and are very pure examples of the Mediterranean race. Many of the subjects dwelt upon are illustrated, and after a short account of Maltese folk-lore, short heads are compared with long. It is common knowledge that these two types exist side by side in this country, and we quote the following observations which Mr. Bradley has made on two of his friends: "I call to mind my longest-headed friend, now no longer living; a man of generous emotions and strong sympathies and antipathies, his fancy led him to lengths from which extrication was difficult, and his changeableness, dependent on his moods, made his conduct alarmingly inconsistent. Yet, when once you knew him well, he was the most loveable of men. Moreover, he was a genius and a poet. I have studied, too, a short-headed acquaintance with much interest; he has no pretentions to brilliance, and never launches forth into enthusiasms or ecstasies. But he is perhaps the most punctual, conscientious, trustworthy person I know. He is, above all things, a safe man, and his greatest merit is his efficiency."

W. M. W.

ASTRONOMY.

The Story of the Heavens, Part I.—By SIR R. S. BALL, M.A., LL.D., F.R.S. In 14 monthly parts. 48 pages. 18 illustrations. 9½-in.×6-in.

(Cassell & Co. Price 6d. net.)

The parts received initiate a new edition of this already well-known book, which first appeared about twenty years ago in a very similar form.

The part before us consists of forty-eight pages with plates and a large frontispiece or chart, in blue, of the northern heavens; so that we may expect a book of about seven hundred pages. From our experience of the early edition, the book was much too thick for convenient handling, by day or by night, so we had it bound into *two* volumes of about one and a quarter inches thick, and they form books that can be used by a child or when reclining in a chair. May we express our wishes strongly to the author and publishers that they will consent to adopt the plan of dividing the book into *two*;

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there need be only one good index at the end of volume II., and a title-page to each; the pages might and should run on.

As we use books for many hours daily we offer this suggestion, and feel sure that the step would be in the right direction and none would regret it; the increased cost would be very trivial, the convenience very great. Books for use are made far too heavy and thick nowadays.

As to the contents; the story is naturally told in the author's most pleasant, entertaining and well-known way, and it comes from a master hand. Judging by the experience of the previous edition the whole ground of astronomy in its popular aspect will be covered. The part before us does not indicate how far the subject has been re-written or revised to date. In future parts that may be judged. In several departments of astronomy, mainly solar and stellar, immense progress has been achieved by that ubiquitous handmaid—photography, and we hope that the advancements may be frequently introduced into the text and plates.

We heartily commend the book to all those who love to read, and to know more about the objects and worlds beyond our own puny Earth.

F. A. B.

Astronomy.—By F. W. DYSON, LL.D., F.R.S. 118 pages. 60 illustrations. 6¾-in.×4½-in.

(J. M. Dent & Sons. Price 1/- net.)

This is one of Dent's Scientific Primers, edited by Dr. J. R. Green. The little book before us is virtually a condensed second edition of the author's larger work upon the subject published in 1910. The only portion that has been materially curtailed is Chapter VIII, on the Fixed Stars, which has been reduced to a microscopical quantity of *six* pages. The bulk of the book consists of three chapters, forty-four pages of historical astronomy, naturally condensed, but replete with information very much to the point and interestingly given; the fourth Chapter we might call the practical chapter, as it relates to the instruments with which astronomers work; the next forty-four pages form Chapters V, VI, and VII, and include the Sun and Solar System, with information to 1908, and numerous illustrations.

Thus we have in about a hundred pages a concise history of astronomy for more than two thousand years, with few omissions of the important facts which form the eras of astronomical progress, in a neat form and size for the side-pocket, if needed, and a few ounces in weight only; also at such a price that half-a-dozen can be bought and given to friends at a cost of a novel.

We advise the reader to study the author's preface, which contains the appreciation—a courtesy often omitted by authors in general—of the author's obligations to other astronomers in enabling him the more readily to produce this excellent little primer, which might well be used as a school book and by teachers themselves. We heartily recommend it, and may the healthy vigour of its youth enable it to reach the maturity of manhood's age.

F. A. B.

CHEMISTRY.

A Treatise on General and Industrial Inorganic Chemistry.—By DR. E. MOLINARI. Translated from the Italian by E. FEILMANN, Ph. D., F.I.C. 704 pages. 279 illustrations. 3 plates. 10-in.×6¼-in.

(J. & A. Churchill. Price 21/- net.)

This book is almost monumental in its scope, for it covers the whole ground of inorganic chemistry, historical, physical, and especially industrial. In some respects it suffers from this fulness, and some of the sections show indications of their severe compression into a single volume of seven hundred pages.

This criticism, however, does not apply to the description of manufacturing processes, which, with few exceptions, are dealt with at length. In fact, the scheme of the book is to unite the applications of chemical reactions more closely with the theoretical aspect than is usual in text books of chemistry.

Full details are, therefore, given of the plant used in the modifications of various industrial processes, and the book not only gains in interest by this plan, but is also valuable as a source of reference for the technical chemist and patent agent.

In most instances the descriptions of the manufacturing processes are up-to-date, but this is not invariably the case. For example, the account of the artificial mineral water industry is very meagre and not entirely accurate. A historical error may also be noted in this connection. It is stated (p. 228) that "the first scientific factory for mineral waters was founded on a scientific basis in 1821 by Dr. Struve at Dresden." This is incorrect; for as far back as the year 1780 artificial mineral waters were scientifically prepared and sold by Professor Bergman in Sweden; and in 1790 a factory for their manufacture was established, also on a scientific basis, by Paul in Geneva.

Another subject that receives too little attention is the chemistry of the rare earths, which is only dealt with very briefly, and in this direction the book would not be a good guide to anyone in search of the latest information.

An excellent feature is the description of the uses to which the various chemical products are applied, and the statistics of the values of the quantities annually manufactured or exported. Naturally, the chemicals of Italian origin receive the fullest treatment, and among the subjects discussed in connection with them is a most interesting account of the present position of the sulphur industry, and its progress since the establishment of the State *Consortio Italiana* to regulate the supply and distribution of sulphur.

The book is excellently printed and illustrated with good diagrams, while the translation is well done. It has deservedly reached its third edition.

C. A. M.

GEOLOGY.

The Work of Rain and Rivers.—By T. G. BONNEY, LL.D., F.R.S. (Cambridge Manuals of Science and Literature.) 144 pages. 19 figures. 6½-in.×5-in.

(The Cambridge University Press. Price 1/- net.)

To the present generation it seems amazing that the formation of river-valleys was once ascribed to anything rather than the rivers which occupy them. Yet, as Professor Bonney shows in the last chapter of this entertaining little book, the true explanation of river-valleys is only a recent addition to scientific knowledge, and the earlier geologists (with the exception of Hutton and a few others) were content to believe that the valleys were made for and not by the rivers. Professor Bonney rightly ascribes to J. B. Jukes the honour of settling beyond question the modern view of the work of rivers in excavating their own valleys; but he perhaps rather exaggerates the influence of the eccentric Colonel George Greenwood, and his book "Rain and Rivers." The rest of the book follows the accepted lines, and while containing little that is new, describes the work of rain and rivers in a way that is bound to excite the interest of the reader. The nature of the treatment may be indicated by the chapter headings—Carving and Carrying, The Making of Valleys, The Transport and Deposit of Materials, The History of a River System, Man's Learning of Nature's Lesson. The author does not approve, as we learn in a footnote, of the modern and extremely convenient terminology which we owe to the genius of Professor William Davis. His illustrations of river-action and history are largely drawn from the Alps, and in the absence of sketch-maps are occasionally not very easy to follow. There is something wrong with the statistics on page 73, where it is stated that a thousand tons of carbonate of lime, if re-converted into chalk, would form a block measuring two feet by three feet at its end and eleven feet in length.

G. W. T.

Preventable Cancer. A Statistical Research.—By ROLLO RUSSELL. 167 pages. 7¾-in.×5¼-in.

(Longmans, Green & Co. Price 4/6 net.)

The above volume well deserves careful study. The writer is not a medical man, and, therefore, when speaking of the

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nature of cancer, is wisely content to quote from various authors whose views agree more or less closely with his own. Then follow some very valuable and carefully-prepared statistics regarding the increase of cancer, its geographical distribution and its relation to trades and occupations, and lastly come the author's conclusions which are perhaps best given in his own words, "The malady shows a real and regular increase in all civilised countries during the last fifty years." "Apart from exceptional customs it scarcely exists among peoples and in districts and countries where the diet is cool, and frugal, without irritating or stimulating adjuncts, the use of water as the staple drink is of effect in immunity." Of the various substances taken as foods, the following are regarded by the author as tending to the production of cancer "fermented liquors, animal and other proteids in long and continuous excess, highly salted and toxic foods and drinks, hot foods and drinks much above blood temperature, and apparently highly acid drinks, such as sour wine and some metals or minerals, of which arsenic is an acknowledged example." A critical examination of the figures quoted by the author makes it very difficult to arrive at any other conclusion than that which we have quoted above. The author is to be warmly congratulated on the very careful way in which he has collected and arranged his statistics.

S. H.

The Doctor and the People.—By H. DE CARLE WOODCOCK. 312 pages. 7¾-in.×5-in.

(Methuen & Co. Price 6/- net.)

In the volume before us we have a series of short essays on everything that appertains to the work of the general practitioner, the doctor of the people. The hospitals, contract practice, the Poor Law, and a host of other subjects, not excluding the National Insurance Act, are all discussed from the point of view of the enlightened general practitioner. "The provincial doctor, and even the Metropolitan, is, like the French peasant, letting the world's controversies rage while he attends to a hundred daily duties of his practice. Sometimes he assists at a tragedy that he cannot prevent, sometimes at one that he can. He is an easy target for the caricaturist, but he does not read the caricature; or if his attention is arrested when Mr. Bernard Shaw attacks him in a whirlwind of wit, he remembers that in the last twenty-four hours he has saved, quite possibly, more than one life. Such is the man I have wished to portray." Again and again have we taken up the book, intending to review it, but so full of interest have its pages been that we have been compelled to continue reading. Some chapters we have read again and again, so excellent is the style in which these are written. The author is no Utopian, but at least some of the faults of our present system he is unable to pass over. Our Poor Law comes in for a large share of reproof, and terrible are his tales of the work of the Poor Law doctors. The infirmaries suffer little better at his hands. "These Poor Law hospitals have been and still are under-staffed; the nurses have not held the highest rank in the nursing world; the doctors have in many cases ceased to be scientific and have become swamped in the small details of hospital management." The admission of medical students and the provision of a staff of visiting consultants to these institutions is strongly advocated.

To the doctor and his patient alike we most heartily recommend this book.

S. H.

PAINTING IN NORTH ITALY.

A History of Painting in North Italy from the Fourteenth to the Sixteenth Century.—By T. A. CROWE and G. B. CAVALCASELLE. Edited by TANCRED BORENIUS. 3 vols. 1339 pages. 207 illustrations. 9-in.×6-in.

(John Murray. Price £3 3s. net.)

The three volumes in which Messrs. Crowe and Cavalcaselle deal with the history of North Italian painting is the complement of their larger work on the history of painting in Italy, which has been for many years in course of republication, and, like it, has been long out of print. Together they form an invaluable and exhaustive compendium of information on Italian art, with which no student can dispense. Crowe and Cavalcaselle pursued their labour of love in the intervals of important official work, and at a time when photography was in its infancy, when handbooks were unknown, when frescoes and paintings now collected in public galleries and museums were still mouldering in the inaccessible remote churches and convents for which they had been painted, a prey to damp and neglect. Those who have read carefully all the republished volumes can only marvel at the industry, the knowledge, the insight, which amounted to genius, in this monumental work. Despite the accumulation of data of various kinds, of lost and forgotten archives, of recovered paintings, which have come to light since its first appearance, editors and commentators of Crowe and Cavalcaselle have astonishingly little to add to or to detract from their decisions. Oftener, where in the then state of knowledge they could only conjecture; subsequent investigations have confirmed their conclusions; while their masterly summaries of the relationship of the art of a painter to his predecessors and successors, and their penetrating criticism, have remained unsurpassed. The volumes which deal specially with painting in North Italy begin with the impetus given to Venetian art by Fabriano and Pisano, and by the Bellini; the paintings of the Bellini, their artistic position and influence, occupy the greater part of the first volume. The second volume opens with the school of Squarcione, whose curious career is unique in the history of painting. A tailor by trade, Squarcione turned his commercial instincts into the channels of art. Acute enough to observe that the religious impulse in art was giving place to the classic revival, he collected models of antiquity, and formed a school of painting for their study. Artists came to it from far and near, and Squarcione derived great kudos from exhibiting their productions under his own name. Among them was the great Mantegna, whose work, like that of many of the later Florentines, bears the impress, in something sculpturesque in its character, of the classic models he had studied. With Volume III we have reached that most mystic and poetic of painters, Giorgione. One special value of these volumes is that the authors have included the artists of many small towns, such as Vincenza, Ferrara, Friuli and Brescia, minor schools which still have their place in the history and development of art.

E.S.G.

PHILOSOPHY.

Modern Problems.—By Sir OLIVER LODGE. 320 pages. 8-in.×5-in.

(Methuen & Co. Price 6/- net.)

The modern problems which Sir Oliver Lodge considers, are chiefly those of philosophy and sociology. Since Professor William James developed the philosophy of pragmatism, with its basic idea that there is no other definition of truth than that "Truth is useful," a great many philosophic doctrines, as well as theologic speculations and scientific hypotheses have been examined by this touchstone. It was, in fact, from a contemplation of the mutable hypotheses of science—mutable in the sense that theory is useful only as it relates facts and must continually accommodate itself to newly-discovered ones—that the basic postulate of pragmatism arose. Sir Oliver Lodge, who is a philosopher almost before being an investigator, and who at any rate has never separated the two rôles, supplies for the pragmatists several solutions of problems in scientific paradox which have engaged their attention. For example, in the essay on "The Nature of Time," he points out that while it might be plausible to argue that, if we regard time as made up of discontinuous instants, we can have no real existence except in the present instant, yet that these "puzzles about duration and succession, about co-existence and sequence, are avoided, or greatly minimized, by recognizing that our direct primary form of apprehension is not either space or time, but *Motion*." From time he goes on to argue, very usefully it seems to us who have wandered rather confusedly between the opposing battalions of the Pragmatists,

the Rationalists and the Intellectualists, that we must have arrived at our conceptions of the Universe by utilization and development of notions derived from our primary and direct sense-perceptions of Motion, of Speed, and of Force. Other essays deal with the philosophy of M. Bergson; with the definition of wealth; with social reforms, and with one of Sir Oliver's most practical contributions to the community's immediate well-being—Smoke Prevention.

E. S. G.

PHYSICS.

The Principia; or the First Principles of Natural Things. To which are added the Minor Principia and Summary of the Principia.—By EMANUEL SWEDENBORG. Translated from the Latin by JAMES R. RENDELL, B.A., and ISAIAH TANSLEY, B.A. With an Introduction by ISAIAH TANSLEY, B.A., and a Foreword by SIR WILLIAM BARRETT, F.R.S. 2 vols. 1340 pages. 104 figures. 8½-in.×5½-in.

(The Swedenborg Society. Price 21/- net.)

Swedenborg is best known, perhaps, by his later philosophical and theological works. But during the last few years an increasing interest has been taken in his earlier works on natural science, it having become apparent that he anticipated some of the important discoveries and theories of modern times in physics and cosmology. This excellent and carefully prepared translation of Swedenborg's *Principia* will, therefore, be welcomed by all physicists and cosmologists who are interested in the history of science. Swedenborg conceived of nature as the expression of the Divine Will, but according to him, this Will always operates according to fixed laws of order and sequence. Consequently, although Swedenborg, as a philosopher, took a transcendental view of nature, regarding it as a miracle; as a worker in science he treated nature as a machine, and attempted to work out a complete theory of natural phenomena based on mechanics and geometry. His position in this respect, is somewhat similar to the attitude of that particularly clear thinker of the present time, Dr. C. Lloyd Morgan.

Whenever experimental facts were obtainable, Swedenborg utilised them. But experimental science was in its merest infancy in Swedenborg's day, and consequently he was frequently obliged to argue *a priori*. This led him, in his *Principia*, to make assumptions, which, nowadays, would not be allowed. Nevertheless, his genius was far in advance of his time, and enabled him more than once to get at the true explanation of phenomena. He was the first to put forward the concept of a vortex-atom. He regarded light as produced by undulations in the ether (a theory already put forward by Huygens, but discredited by Newton). He also regarded heat and electricity as having an etheric origin. His explanation of the reason of the magnetisation of iron, by stroking with a magnet, is perfectly correct; and his words on this point might, as Sir William Barrett points out in his valuable and appreciative Foreword, be those of a modern student. Moreover, his explanation of the orgin of the solar system must be regarded as an anticipation of the theory of Laplace. Indeed, Swedenborg seems to have been a man of extraordinary mental abilities, whose works have been too much neglected. An Appendix containing critical and explanatory notes by Professor Very adds to the value of the present translation.

H. S. REDGROVE.

RADIOACTIVITY.

Radioactive Substances and their Radiations.—By E. RUTHERFORD, D.Sc., F.R.S. 699 pages. 8¾-in.×6-in.

(The Cambridge University Press. Price 15/- net.)

It is eight years ago since Professor Rutherford published what was rightly regarded as the authoritative work on the emanations of radioactive substances, and from that volume many which have been written since are largely derivative. In 1904 the theory of the disintegration of the atom, of which Rutherford made use to explain the phenomena of the expulsion of atoms and electrons, and of rays as yet not entirely accounted for, was still under discussion. Lord Kelvin was not entirely convinced; and there was an alternative theory, not without advocates, which was that the energy of radium was first taken in from an external source, and was than transformed into radioactive energy by a kind of surface osmosis. Professor Rutherford's answer to this suggestion was to dissolve a speck of radium bromide in a solution of radium chloride which was a thousand times the speck of radium's bulk, and then to show that there was no alteration in the rate or quality of the radiation such as there should have been if the radiation had been dependent on external sources of energy.

One recalls the experiment as something almost archaic, so soundly now does the disintegration theory seem established. But it is of importance to notice the rate at which confirmation of the theory grew. Confirmation was given to it by the increasing knowledge of the transformations which radium and other radioactive substances underwent, because it was evident that the mechanism of transformation was the same or similar in succeeding cases, and with the accumulation of instances it became clear that the idea of unstable atoms disintegrating under the influence of a disturbance to the units of their atomic systems, was the only one which would cover all the cases. In 1905 twenty of these transformations in radioactive substances were known. The number now is thirty-two, and Professor Rutherford remarks that there is some evidence to show that a few transformations still remain undetected. They are not easy to find, because the transformations are so extremely rapid: and in consequence the lives of the elements produced by them are extremely short. Radium has a life of respectable proportion, though it is so far below the career enjoyed by its venerable ancestor Uranium: but the one thousand seven hundred and sixty years which are the "half-life of radium," are a comparative immortality by the side of the lifetime of that element derived from the emanation of thorium, whose life is only fourteen-hundredths of a second, or of the actinium derivative, the lifetime of which is one five-hundredth of a second.

These are some of the results of the eight years of investigation conducted in every physical laboratory of the world, and summarised in what is, in all respects but that of theory, a new volume. The eight years, however, besides affording a vast amount of information, have been fecund in new methods and in new ideas. The most singularly useful of the new methods is, perhaps, that due to the discovery of ways of counting single α particles. This has not merely extended the knowledge of the α particle, but it has been of the greatest importance in obtaining accurate data for the calculation of a number of important radioactive quantities and atomic magnitudes. It must not be forgotten that it is since 1904 that physicists have learnt to weigh the negative corpuscle.

Again, the discovery of the recoil of radioactive particles when an α particle has been expelled, has proved to be useful as a means of separating radioactive substances: it has also furnished a new kind of corpuscular radiation for study. The importance of secondary radiations; the light they throw on a possible positive particle of electricity; the nature of gamma rays and their probable identity with Röntgen rays—these are the things which are now of most importance in the study of radioactivity. To them all, as well as to the influence which emanations of radioactive substances exert on the electrical state of the atmosphere, Professor Rutherford gives exactly the right kind of judgment and consideration. His new work is one of those which are inevitably and indubitably standard works: and the only corollary we could have wished to add to it would be a more extended consideration of Professor Bragg's theory on the nature of "electric doublets" and the Röntgen rays.

H. S. REDGROVE.

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YEAR BOOKS.

Who's Who, 1913.—2,226 pages. 8⅛-in. × 5½-in.

(Adam & Charles Black. Price 15/- net.)

"Who's Who" comes to us this year in an enlarged form, and contains no less than twenty-five thousand biographies. Its great usefulness is made thereby still greater, and the chances of anyone not finding within it what they seek are considerably lessened. As would be expected, many men of science are included, and the records of their lives, brief though they are, make very interesting reading. Some of them seem to consider that they have no need for recreation, and probably that is true of many enthusiasts, but others, like the generality of people, tell us how they get relaxation. One well-known zoölogist gives as his recreations, conversation in clubs and tricycling. An American evolutionist boldly states that he gets his recreation in work. A distinguished German physicist spends his spare time in climbing the Alps, to which passion he says he has clung for almost his whole life. "Who's Who" should be on the shelves of every intellectual person and in every office of any importance.

Whitaker's Almanack, 1913.—By JOSEPH WHITAKER, F. S. A. 1,036 pages. 7½-in. by 5-in.

(Price 2/6 net. Paper 1/- net.)

Almost everything that can be said in praise of "Whitaker" has been printed in the many years during which it has been before the public. The valuable astronomical information which it contains would entitle it to a notice here, even if on its general merits it did not claim its annual welcome. To us, perhaps, its greatest usefulness lies in giving us the names of various officials who carry on the scientific and educational work of the Government, and that is but one point among many thousands which others have come to appreciate.

Whitaker's Peerage, 1913.—854 pages. 7½-in. × 5¼-in.

(Price 5/- net.)

With Whitaker's Almanacks comes "Whitaker's Peerage," which is of a convenient size, reasonable price, and handy to use, because it has one alphabetical list of everyone who has a title or who has gained a decoration.

The International Whitaker, 1913.—529 pages. 7¼-in. × 5-in.

(Price 2/- net.)

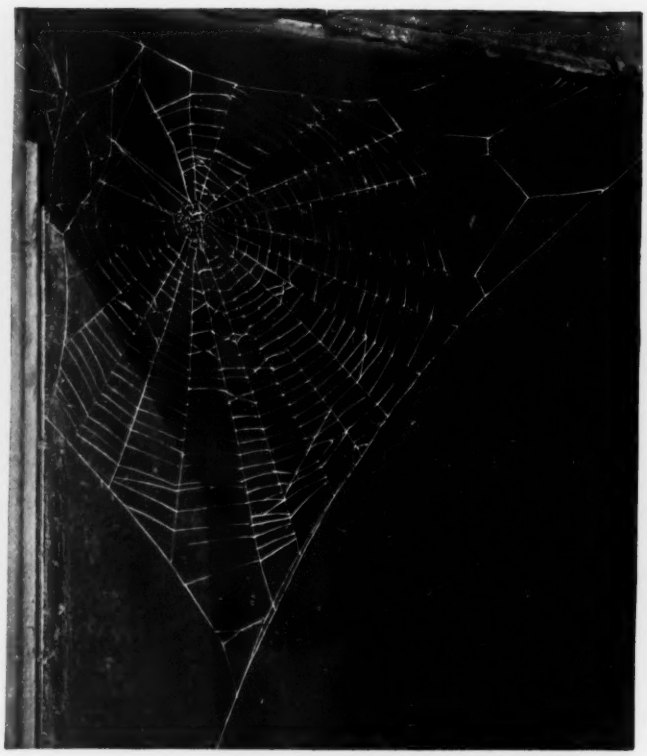
The "International Whitaker" is a new year book, which gives information something similar to that of the old "Whitaker" with regard to our colonies and the various countries of the world. As may be imagined, it is particularly intended for English-speaking people, and it contains an interesting biographical note concerning the originator of "Whitaker's Almanack," which it is to supplement, but not to supersede. We anticipate for it a most successful career.

ZOÖLOGY.

Spiderland.—By R. A. ELLIS. 108 pages. Numerous plates. 7¾-in. × 5¼-in.

(Cassell & Co. Price 3/6 net).

As would doubtless be judged from its title, this popularly written book is intended for young people, and we may add that it will fulfil its object. Its author's claim that there are few books dealing with the life of spiders is a good one; occasionally in nature study volumes a chapter may be devoted to the creatures in question, and the writer of this notice when a boy found that they were one of the things that could be studied with interest and advantage in a town garden.



By the courtesy of *Messrs. Cassell & Company.*

FIGURE 69.

A Sectional Web spanning an open doorway. (From "Spiderland.")

In "Spiderland" a very clear description is given, when dealing with structure, of the conformation of the spinnerets, and not the least attractive parts of the book are those which are concerned with the weaving of snares.

Occasionally one meets with a sentence which sounds more effective than accurate: as, for instance, in the one which states that spiders "banquet on the ruddy drops that warm the hearts of their insect prey." Moreover "protective resemblance" is the proper term to use when speaking of the likeness of the spider to its natural surroundings. It is difficult to "mimic" a flower or a twig. The author has been allowed to make use of the writings of the late Dr. McCook, and the following incident recorded by him is given:—"An Englishman, being pursued by Red Indians, sought refuge in the hollow of an old tree. While hiding there he saw a spider begin to weave her web over the entrance. Within a very short space of time the orb was completed and the little weaver took her station in the centre. No sooner had she done so, than a Red Indian came by. He approached the hollow tree, tomahawk in hand, but noticing the web with the spider in the centre, naturally concluded that there was no tenant there."

There are many excellent illustrations and the volume altogether forms a valuable addition to a boy's or girl's collection of "nature books."

W. M. W.

Wild Life.—Edited by DOUGLAS ENGLISH. Volume I, Number 1. 64 pages. Numerous illustrations. 12¼-in.×9¾-in.

(The "Wild Life" Publishing Co. Price to subscribers, 17/6 for six months, 30/- for twelve.)

Wild Life is a new illustrated monthly magazine of which the letterpress is to be based solely on first-hand observation, and the illustrations are to be from photographs alone. It is the outcome of the widely-spreading cult of Nature photography, and, more immediately, of the exhibition of the work of the Zoölogical Photographic Club, held at the offices of the Zoölogical Society last summer. The first number now before us is most excellent, and it is probable that the future ones will be even better; for an editor, as he proceeds, becomes more and more critical with regard to the perfection of the photographs which he chooses, and the way in which they are reproduced. Mr. Farren's photographs and account of the nesting Egrets, which flourish not more than a three-days' journey from London, are delightful. We reproduce, by permission, one of the photographs taken by Mr. Douglas English to accompany his remarks on "The Wild Cat" (see Figure 70). Dr. Francis Ward's observations and pictures illustrating "Photography under Water" are very interesting, and there is much good work by other well-known photographers. Two of Mr. R. B. Lodge's "Eagles" are noteworthy; the third is too obviously touched up, and his Griffon Vultures are not successful. The carrying of the letterpress right across the wide page gives a certain style to the publication, but the lines are too long for easy reading. *Wild Life* marks an epoch in the modern study of Nature, and we wish it every success.

W. M. W.

From a photograph by Douglas English.

FIGURE 70. The Wild Cat.

(From "Wild Life" by the courtesy of the Editor.)

NOTICES.

BIRDS IN AVIARIES.—Those who are interested in the acclimatization of foreign birds will find a good deal of interesting matter in Mr. Wesley T. Page's "Aviaries, and Aviary Life," in which many of the birds, with nests which have been built in this country, are illustrated. It is published by the Avian Press, Ashbourne.

FORMALIN AS AN INSECTICIDE. — Experiments have been made at University College, Cork, to determine the insecticidal power of formaldehyde. Various strengths from ·01 to 2 per cent. were used, but the results, we learn from *The Irish Naturalist*, show that any efficacy which formalin might possess as an insecticide is more than counterbalanced by its injurious action on the plant.

EGG OF THE GREAT AUK.—Mr. Thomas Parkin contributes to *British Birds* for January an account of the very finely marked egg of the Great Auk, which was sold at Stevens's, on November 21st, 1912, for two hundred and twenty guineas, to Messrs. Rowland Ward, Ltd. It was the property of Mr. W. Sheppard, of Bristol, in 1807, and purchased by Mr. Shirley, of Ettington, about 1820. It was put up for auction in 1910, when Mr. E. L. N. Armbrecht bought it for £262 10s.

PAUL RAINEY'S EXPEDITION TO SOUTH AFRICA.—The most remarkable set of moving pictures obtained on Mr. Paul Rainey's expedition are now on view at the Holborn Empire, in London, and cannot fail to interest anyone who takes the trouble to go and see them. The naturalist would, of course, be most pleased with the striking films obtained near a water hole, which show several rhinoceroses, two giraffes, a family of elephants, numerous deer, monkeys, and many birds. Sportsmen would appreciate the hunting of cheetahs and lions by means of dogs, and it must be added that Mr. Reginald Carrington's descriptive lecture is most lucid and explanatory.

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SECOND-HAND INSTRUMENTS.—More than fifteen hundred pieces of scientific apparatus for sale, or on hire, are given in Mr. C. Baker's current list of second-hand instruments. We have often alluded to the usefulness of these catalogues and commend the present issue to our readers. On one of the advertisement pages we notice the announcement of a new one-sixteenth inch oil immersion objective, the price of which is £6 10s.

PORT ERIN BIOLOGICAL STATION.—Professor Herdman's Annual Report of the work done at Port Erin Biological Station is always interesting, and the twenty-sixth one which has come to hand is particularly valuable because it contains a number of maps, charts, and plans of Port Erin Bay and the neighbourhood, prepared for the use of advanced students or research workers, on which they can record localities and captures.

BRITISH ASSOCIATION ADDRESSES.—A correspondent signing himself O.B.L. sends us the following note.—"I see from the *Publishers' Circular* an announcement to the effect that Messrs. Longman are publishing 'The only authorized address of the President of the British Association' delivered at Dundee. From this are we to assume that the copies of the address sold by the association to the members at Dundee, and that the version which appears in the Annual Report in about a year's time, are unauthorised?"

HORNIMAN MUSEUM LECTURES.—The following Saturday afternoon lectures will be given at the Horniman Museum during February.—

Feb. 1st.—	"Tools and Weapons of the Old Stone Age"	DR. H. S. HARRISON (Curator of the Museum).
„ 8th.—	"The Gun-flint Industry of Brandon: a Survival of the Stone Age"	MR. EDWARD LOVETT (of the Folk-Lore Society).
„ 15th.—	"Japanese Ivories and Designs" ...	MR. A. R. WRIGHT, F.R.A.I.
„ 22nd.—	"The Day's Work of a Root"	DR. E. MARION DELF.

HINTS ON PHOTOGRAPHY.—We have received from Messrs. Charles Zimmermann & Company the "Agfa" handbook, which is published by the photographic department of the Actien-Gesellschaft für anilin-fabrikation, Berlin, containing a number of chapters by well-known English photographers on such subjects as time development, rodinal for the development of gaslight papers, and exposure meters. Messrs. Zimmermann will send a copy on receipt of a penny stamp.

EGYPTIAN LEGENDS.—The forthcoming book in Mr. Murray's "Wisdom of the East" Series is "Ancient Egyptian Legends," translated by Miss M. A. Murray, the well-known lecturer on Egyptian Literature, of University College, London. The author has given a free rendering of the fascinating legends of the ancient Egyptian Gods, Isis, Osiris, Horus, Ra, telling of their loves, battles, prayers, adventures, and sacrifices, which are likely to appeal to a wide public, while at the same time in her notes on the subject she has made provision for the more serious student.

MEDICAL BOOKS.—Messrs. Adam and Charles Black will, in future, publish the following medical books which were formerly issued by Mr. James Currie, Edinburgh.—"Handbook of Medical Treatment; A Guide to Therapeutics for Students and Practitioners, with an Appendix on Diet," by James Burnet, M.A., M.D., M.R.C.P.E.; "Manual of Medical Jurisprudence, Toxicology, and Public Health," by W. G. Aitchison Robertson, M.D., D.Sc., F.R.C.P.E., F.R.S.E.; Second edition, with thirty-nine illustrations, crown octavo. "The Pocket Clinical Guide," by James Burnet, M.A., M.D., M.R.C.P.E.; "The Pocket Prescriber," by James Burnet, M.A., M.D., M.R.C.P.E.

A PHILATELIC MICROSCOPE.—We have received from Mr. Harold Cheavin a description of the inexpensive microscope which he has designed for philatelic workers, and recently exhibited before the Royal Microscopical Society. The microscope will prove useful in examining small details which are of great importance to stamp collectors, and by a simple adjustment, water-marks may be made out as well as the texture of the paper used. It is also very easy to fit the microscope into the front of a camera from which the lens has been removed, and so to take any photo-micrographs that may be required. The instrument is made by Messrs. Watson & Sons, but all communications should be addressed to Mr. Cheavin, Somerset Road, Huddersfield.

THE PRESERVATION OF FLORA AND FAUNA.—It will be remembered that at the Dundee meeting of the British Association in September last the President of the Zoölogical Section, Dr. P. Chalmers Mitchell, F.R.S., took as the subject of his address: "The Preservation of Fauna." At the close of the meeting the General Committee passed on to the Council, for consideration, a resolution, which has now been adopted, in the following terms:—"That the British Association for the Advancement of Science deplores the rapid destruction of fauna and flora throughout the world, and regards it as an urgent duty that steps should be taken, by the formation of suitably-placed reserves or otherwise, to secure the preservation of examples of all species of animals and plants, irrespective of their economic or sporting value, except in cases where it has been clearly proved that the preservation of particular organisms, even in restricted numbers and places, is a menace to human welfare.

THE ALCHEMICAL SOCIETY.—The first general meeting of the Alchemical Society, which has been formed for the study of the works and theories of the Alchemists in their various aspects, was held on Friday evening, January 10th, at the International Club, Regent Street, W. The Hon. President of the Society is Professor John Ferguson, M.A., LL.D., F.I.C., F.C.S., and amongst other notable members we may mention Mr. H. Stanley Redgrove, B.Sc., F.C.S., Mr. Arthur Edward Waite, Mr. W. Gorn Old, Mr. Philip S. Wellby, M.A., and Madame Isabelle de Steiger. At the meeting a lecture was delivered by Mr. H. Stanley Redgrove, B.Sc., F.C.S. (whose "Alchemy, Ancient and Modern," is well known to students), on "The Origin of Alchemy." The lecturer pointed out that the alchemists in the past had been too harshly condemned as half charlatans, half fools. As he said, although some of them were of this nature, many of the alchemists were men of fine intellect and inspired in their studies with noble ideals; and he suggested that, in spite of the fact that their assumptions led them into many fantastic errors, they did seem to grasp certain fundamental facts concerning the universe of very great importance. But, even supposing their theories to be utterly wrong, it was still necessary to account for the fact that they gained almost universal credit. Why, asked the lecturer, did the alchemists adopt such views concerning natural phenomena? Here, he said, was a proper subject for scientific investigation. His reply, which he illustrated at considerable length, was that the alchemists started with two assumptions: (1) the truth of mystical theology, especially the doctrine of the soul's regeneration; and (2) the truth of the statement that natural objects are the symbols of spiritual verities. They, thus, reasoning *a priori*, attempted to explain natural phenomena by the application to them, by analogy, of the principles of mystical theology.